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ORIGINAL ARTICLES.

I.—On a Collection of Trilobites from the Coddon[1] Hill Beds, Lower Culm-measures, near Barnstaple, North Devon, and one from Glamorganshire.

By Henry Woodward, LL.D., F.R.S., F.G.S.

(PLATE XX.)

HAVING some time since been favoured by Mr. and Mrs. Coomáraswámy (Miss Ethel M. Partridge) and Mr. Joseph G. Hamling, F.G.S., of Barnstaple, with the loan of their collections of Culm Trilobites from Coombe Wood, etc., near Barnstaple, I feel it incumbent to add a few notes to those already published by me in the Appendix to Messrs. Hinde & Howard Fox's paper (Quart. Journ. Geol. Soc., 1895, vol. li, pp. 646–649, pl. xxviii, figs. 1–8).

Out of the large series of specimens kindly sent to me, I have selected and figured on Plate XX thirteen of the best preserved examples from the Coombe Wood section; whilst Figs. 14 and 15 illustrate a nearly entire Trilobite, obligingly lent to me by Mr. Frederick Barke, F.G.S., of Stoke-on-Trent, and obtained by him from beds of reputed Culm age at Bishopston, Glamorganshire.[2]

Phillipsia, sp. (Pl. XX, Figs. 1, 2, and 13 (?).)

Fig. 1 represents the glabella of a *Phillipsia*, with the fixed cheek attached, of the natural size. The glabella measures 16 millimetres

[1] Spelt *Coddon* Hill by H. B. Woodward (Geology of England and Wales), also in the best Gazetteers and on the Geological Map of England and Wales; but *Codden* Hill on the Ordnance Survey Map.

[2] For previous papers on these Trilobites from the Culm, see:—Henry Woodward, "On the Discovery of Trilobites in the Culm-Shales of South-East Devonshire": Geol. Mag., 1884, pp. 534–545, Pl. XVI. H. Woodward, "Carboniferous Trilobites": Mon. Pal. Soc., 1883–84, pp. 1–86, pls. i–x (on the Culm Trilobites, pp. 55–70, pl. x). G. J. Hinde & Howard Fox, "The Radiolarian Rocks in the Lower Culm-measures of Devon, Cornwall, and West Somerset": Quart. Journ. Geol. Soc., 1895, vol. li, pp. 609–668, pls. xxiii–xxviii (Note on the Trilobites, by H. Woodward, pp. 646–649, pl. xxviii, figs. 1–8).

in length, and is 10 mm. in breadth at the posterior border; it diminishes slightly to 9 and 8 mm. respectively, 10 and 11 mm. from the posterior margin, and is marked by three recurved furrows on each side; the hindermost cuts off a small semicircular lobe which is enclosed by it and the latero-posterior angle of the glabella. The glabella is rounded, and does not expand in front; it is separated from the anterior border by the flattened margin of the fixed cheek, which is 3 mm. broad; the fixed cheeks are 4 mm. broad on each side of the glabella, where anteriorly they form a rounded lateral expansion, contracting to 1 mm. in breadth just in front of the eye and broadening to 2 mm. on the superciliary region; thence, after a slight contraction, it again expands to a breadth of 5 mm. at its union with the posterior margin. The nuchal furrow is not very clearly defined and the free cheeks are not preserved.

This glabella and the pygidium, Fig. 12, represent fragments of some of the largest Trilobites hitherto obtained from the Lower Culm of Coddon Hill.

Although much larger in size than *Ph. Polleni*, from the Carboniferous (Culm ?) Shale-beds of the river Hodder, at Stonyhurst (see Geol. Mag., 1894, p. 487, Pl. XIV, Figs. 7–12), I am nevertheless inclined to refer this glabella to that species, possibly also the detached cheek, Fig. 13.

Fig. 2, although smaller (being drawn twice nat. size), probably from its form, may likewise be referred to *Ph. Polleni*.

These fragments may serve to suggest the probable presence of this species at Coddon Hill.[1]

Phillipsia spatulata, sp. nov. (Pl. XX, Figs. 3, 4.)

The head in this species is remarkable for the peculiar form of the cheek-spines, which have a broadly rounded and expanded extremity quite unlike that of any other Trilobite from this locality. The length of the head-shield in Fig. 3 measures 12 millimetres, and the breadth at its base 18 mm. The length of the head to the end of the cheek-spines is 20 mm. These spines extend backwards 8 mm. beyond the base of the head, being nearly 3 mm. broad, and are striated longitudinally upon the under surface. The glabella is 6 mm. broad at its base, the sides are nearly parallel, with a slight expansion and tumescence in front; the fixed cheeks are narrow; they form a border of about 1 mm. in width around the glabella in front. Owing to the state of preservation of these specimens the eyes cannot clearly be made out, but they are about 6 mm. from the posterior border of the glabella; the free cheek is semicircular in outline, with a broad margin which widens perceptibly backwards to the posterior angle, where the spatulate cheek-spine originates.

There are two small triangular lobes at the base of the glabella and a minute tubercle which marks the centre of its posterior

[1] The species hitherto recorded (see Quart. Journ. Geol. Soc., 1895, vol. li, pp. 646–649) are:—*Phillipsia Leci*, H. Woodw.; *P. minor*, H. Woodw.; *P. Cliffordi*, H. Woodw.; *Phillipsia*, ? sp.; *Griffithides acanthiceps*, H. Woodw.; *G. longispinus*, Portl.; *Proetus*, sp. (*a*, *b*).

border; the neck-furrow is not clearly seen in Fig. 3, but a portion is visible in Fig. 4, 1 mm. in width.

Fig. 3 shows an entire head-shield from the Coombe Wood Quarry collected by Mr. A. K. Coomáraswámy, F.G.S., and has a counterpart. Fig. 4 is from Mr. J. Hamling's collection (No. 704) from Overton Quarry. There is also a free cheek and spine (No. 712) from the same collection, Coddon Hill. On re-examining the earlier material in the British Museum (Natural History) I find another very good head-shield and counterpart (registered I. 3215) of this species, presented by Mr. Joseph Hamling, F.G.S., in 1896, from the Culm of Coddon Hill, Barnstaple.

PROETUS, Steininger, 1830.[1]

PROETUS CODDONENSIS, sp. nov. (Pl. XX, Figs. 5–11.)

I have spent much time in the examination of these small Trilobites from Coddon Hill, Barnstaple, of which, thanks to Mr. J. G. Hamling and Mr. and Mrs. Coomáraswámy, I have received a large number of specimens. I selected Figs. 5, 8, and 11 as the most perfect examples, the heads Figs. 7, 9, and 10, and the pygidium, Fig. 6, all of which I had reasonable expectations were distinct. I regret to have to admit that my first impressions are not borne out by a more lengthened study of the materials; on the contrary, I am now led to conclude that they must (notwithstanding various minor differences) all be placed in the same species.

These fragmentary remains number about 75 specimens, and consist, for the greater part, of detached heads and tail-shields, only about 21 examples having at least some of the thoracic segments also preserved, 8 only being complete. These Coddon Hill specimens are all extremely small, Fig. 5 being 6 mm.; Fig. 8, 9 mm.; and Fig. 11, 10½ mm. in length.

The head-shield is semicircular; eyes never well preserved, but where visible reniform; glabella slightly broader behind, rounded in front, marked by two triangular lobes at the base; fixed cheeks narrow at sides; glabella separated from margin of shield in front by the smooth or striated border of the fixed cheek. The facial suture which divides the fixed cheek from the free cheek crosses the frontal border just in a line with the eye, above which it expands, forming a rounded palpebral lobe; then passing down close to the line of the axial furrow, it diverges outwards and crosses the posterior border obliquely behind the line of the orbit. Free cheeks roundly triangular, centre of the cheeks raised; margin smooth and broad, produced into a short spine at the posterior angles; neck-lobe corresponding with the free thoracic segments in its axial portion. Free thoracic segments number 7 in Fig. 5, 8 in Fig. 8, and 8 or 9 in Fig. 9. This discrepancy, which I at first regarded as of specific value, if no more, I now conclude to be due to squeezing together of the segments in Figs. 5 and 8, so as to conceal their full number.

[1] For a full description of the genus PROETUS see H. Woodward, "Carboniferous Trilobites": Mon. Pal. Soc., 1884, pp. 55–57.

I have detected the *overlapping* clearly in some of the other unfigured examples of this species in the collection, due to squeezing together of the thoracic rings.

Fig. 11 is no doubt the most complete of the three, Fig. 5 having been shortened by squeezing together *longitudinally*, which has given it a greater lateral expansion.

In all these specimens the body axis is considerably broader than the pleuræ, and the trilobation is very strongly marked. The pleuræ are strongly recurved, falcate, and their extremities rounded and broadly faceted.

The pygidium is very short, the axis is truncated and does not reach the posterior border, the coalesced segments are obscure, but appear to be about six or seven in number, the margin when preserved has a well-marked rim (see Fig. 11).

Although in the genus *Proetus* there are several species having a larger number of coalesced segments in the pygidium than are seen in this form from Coddon, yet there are many others with an equally short pygidium. On the other hand, there is *no Phillipsia nor Griffithides* with such a shortened tail-shield, nor can the head-shield, although certainly less well preserved, be referred to either of these genera.

Several forms, at present within the genus *Proetus*, will undoubtedly have to be removed whenever this genus is revised.

PROETUS, sp. (Pl. XX, Fig. 12.)

This large pygidium, in which the traces of coalesced segments are almost obliterated, is figured on our plate of the natural size. It measures 29 mm. in width, by 15 mm. in length; the surface is very convex, the axis is 11 mm. broad at its union with the free thoracic segments, and diminishes to 4 mm. near its rounded distal extremity, which almost touches the posterior border. Traces of about two or three coalesced segments can be discerned near the proximal border. The outer margin had a raised thickened rim. The late Professor James Hall, in his "Palæontology of New York," has figured a somewhat similar smooth pygidium, which he named *Proetus crassimarginatus*, from the Upper Helderberg Group (Devonian),[1] but it is longer in proportion to its breadth than is our Coddon Hill specimen. There are no free segments or head-shields known from this horizon which can be relegated to this pygidium; I do not therefore propose to give it a name. It may, for the present, be referred to the genus *Proetus*.

As a large number of these Culm-measure Trilobites are more or less in the condition of compressed and distorted casts, it is often very difficult to determine accurately their minute characters; it is better, therefore, to defer a fuller description of them until, as is to be hoped, more perfect materials are obtained.

GRIFFITHIDES BARKEI, sp. nov. (Pl. XX, Fig. 14.)

This is a characteristic example of the genus *Griffithides*, and may

[1] Pal. New York, 1888, vol. vii, pl. xx, fig. 8.

be compared with *G. longiceps* of Portlock, from the Carboniferous Limestone of Ireland, but the Irish species attains to almost twice the size of Mr. Barke's example from Glamorganshire.

The general outline is ovate-oblong; the glabella is smooth, very gibbous, and pyriform; the basal lobes are rather small and obtusely triangular, and not nearly so prominent as in *G. longiceps*; the axial portion of the neck-lobe is moderately broad, and separated from the glabella by a well-marked smooth furrow; the fixed cheeks are very narrow, but the suture is not distinctly seen in the specimen anteriorly; eyes one-third the length of the head, reniform, surface finely faceted; raised inner portion of free cheeks rather narrow, surface smooth, outer margin wide, posterior angles produced into broad and stout spines, reaching to the 6th segment of the thorax; thorax composed of nine free segments, the axis arched, equalling one-third the breadth of the thorax, each segment of the axis having a row of minute granules along its posterior border, none visible on the pleuræ; angles of pleuræ bluntly terminated (not rounded as in *G. longiceps*); pygidium composed of thirteen coalesced somites, the posterior margin of the axis of each one bearing a row of minute granules, similar to those on the axis of the free segments; axis tapering to the extremity, and rather more pointed and more slender than in *G. longiceps*; ribs nine in number, not granulated, separated from the lateral margin by a broad, striated border, which is widest posteriorly. [The Hypostome.—Fig. 15 on Plate XX represents the hypostome seen *in sitû* in the head of Fig. 14. It closely resembles the hypostome of *Griffithides*, see H. Woodward's Mon. Carb. Trilobites: Pal. Soc., 1883, p. 30, pl. vi, fig. 5, which may have belonged to *G. longiceps*.]

Compared with the species nearest to it *G. Barkei* differs from *G. longiceps* in the following particulars:—

The glabella in *G. Barkei* is broader in proportion *anteriorly* and narrower and more pointed posteriorly than in *G. longiceps*; the basal lobes are smaller and much less prominent; the eyes are placed slightly more posteriorly, and abut upon the basal lobes and the neck-lobe; there is no tubercle on the basal lobe; the row of minute granules on the posterior border of each segment is confined to the axis of both the thorax and the pygidium; the pleuræ are bluntly terminated, not rounded; lastly, the ribs in the pygidium do not reach the margin as in *G. longiceps*, but are separated by a broad (striated) margin which widens posteriorly. These differences, together with its much smaller size, suffice to separate *G. Barkei* specifically from *G. longiceps*, than which there is no other so closely related to it. I have much pleasure in naming it after its discoverer, Mr. Frederick Barke, F.G.S., of Stoke-on-Trent.

Concerning the horizon of *Griffithides Barkei*, Dr. Wheelton Hind writes:—"It was obtained at Bishopston, Glamorganshire, from a series of desilicified cherts which rest upon the Carboniferous Limestone massif, and immediately overlying which are beds with fossils of the Pendleside series. These cherts would be very close to the horizon of the beds on the Hodder at Stonyhurst, where

Trilobites occur,[1] and these beds, I strongly suspect, will soon be shown to be of about the same age as the Culm. The number of fossils common to this part of the Culm and Pendleside series is very remarkable: *Posidonomya Becheri, Goniatites* (*Glyphioceras*) *sphæricus, G. spiralis, G. striatus*," etc.

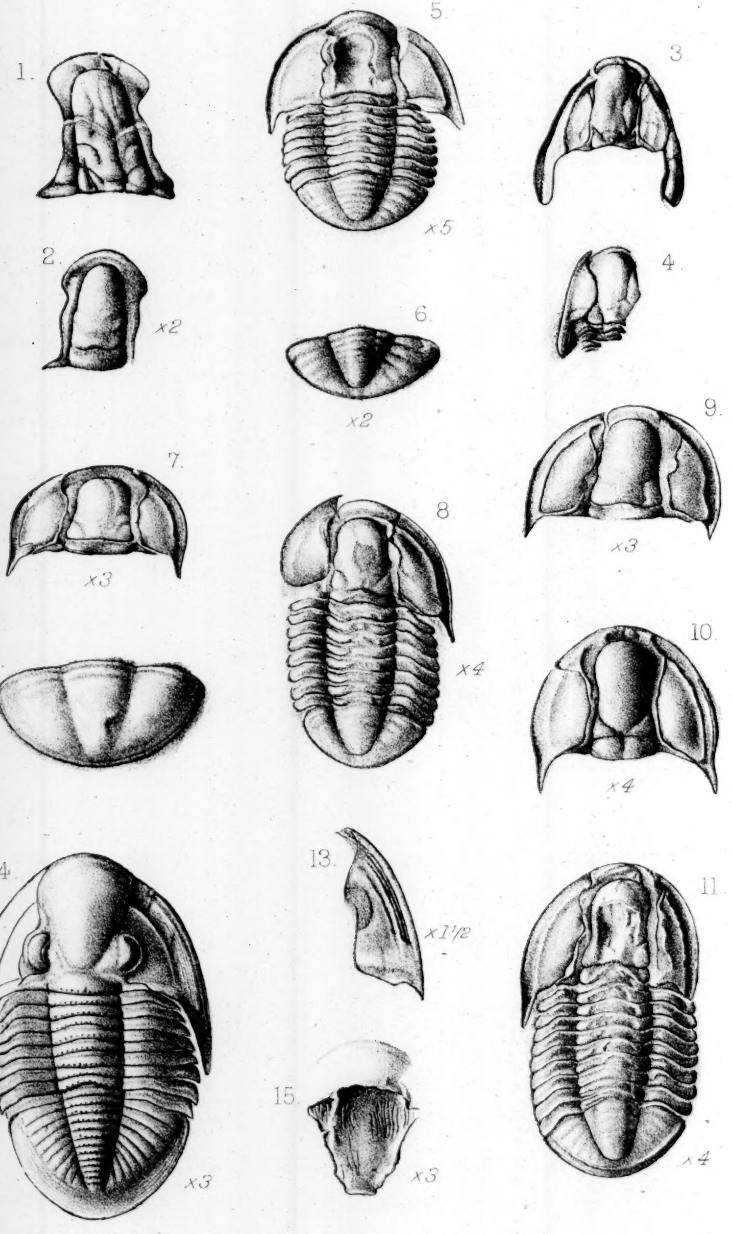
Mr. Horace B. Woodward, F.R.S. (Geology of England and Wales, 2nd ed., 1887, p. 167) writes:—"In Glamorganshire, immediately above the Carboniferous Limestone of Gower, at Penrice, and between Llanrhidian and Oystermouth, there is a considerable development (1,600 feet) of black shales with sandstones, to which the name Gower series has been applied. These beds appear to represent the Upper Limestone shales and perhaps the Millstone Grit. At Tenby they are but a few feet thick, but there they contain beds of dark limestone, and yield *Goniatites*, reminding one of the Black Limestones of North Devon that occur at the base of the Culm-measures." Further on (p. 172) he adds: "The Millstone Grit is not definitely identified in the Gower peninsula, and it remains to be proved whether the Gower shales should be correlated with it, or whether it be represented by certain sandstones above them and now included with the Coal-measures."

So far back as 1846, Sir H. T. De la Beche describes this very section at Bishopston, Glamorganshire, and gives a measured section of the beds. He writes (Mem. Geol. Survey, vol. i, pp. 133 and 143):—

"It is desirable to mention certain beds which occur above the Carboniferous Limestone near Swansea (if, indeed, they may not, in a great measure, be as an upper portion of it), since there is a certain general resemblance between them and the beds in Devonshire immediately above the Pilton Group. When these beds reach the coast in Swansea on the east, the section exposed is not good, and the beds are also concealed where the coastline cuts them towards Caermarthen Bay on the west; but fortunately they can be well studied along the course of the river near Bishopston" (p. 133). (Here follows the section.) He adds further on:—

"At Swansea we observe a development of the black shales and cherty grits above noticed, fining off at Tenby, where we see black limestones with *Goniatites*, the whole of these beds so intervening between the more solid Carboniferous Limestone and Coal-measures appearing as if they were a continuation of the black limestone group of Devonshire, above the Pilton and Petherwin groups, thus extending, locally modified, into South Wales. Under this view the close of the Carboniferous Limestone epoch would, in South-Western England and South Wales, be marked by a mixed deposit of limestone in one part, an alternation of sands, mud, and limestone in another, and by sands, black mud, and Carboniferous limestones in a third" (p. 143).

[1] See H. Woodward, "On a Collection of Carboniferous Trilobites from the Banks of the Hodder, near Stonyhurst, Lancashire": Geol. Mag., 1894, Dec. IV, Vol. I, pp. 481–489, Pl. XIV.



G.M.Woodward del et lith. West, Newman imp.

Carboniferous Trilobites, *Devon, etc.*

EXPLANATION OF PLATE XX.

FIG. 1. *Phillipsia Polleni* (?). Lower Culm-measures: Coombe Wood, Coddon Hill, near Barnstaple. Nat. size. Mrs. Coomáraswámy's (Miss E. M. Partridge) collection.
,, 2. Ibid. Hannaford Quarry. × 2.
,, 3. *Phillipsia spatulata*, sp. nov. Same form.: Coombe Wood. Nat. size. Mr. Coomáraswámy's collection.
,, 4. Ibid. Overton Quarry. Nat. size. Mr. J. G. Hamling's collection.
,, 5. *Proetus Coddonensis*, sp. nov. Entire specimen. Lower Culm-measures: Coombe Wood, near Barnstaple. × 5. Mr. Coomáraswámy's coll.
,, 6. Ibid., pygidium. Hannaford Quarry. × 2. Mrs. Coomáraswámy's coll.
,, 7. Ibid., cephalon. Coombe Wood. × 3. Coll. ditto.
,, 8. Ibid., entire specimen. Same form., loc., and coll. × 4.
,, 9. Ibid., cephalon. Same form., loc., and coll. × 3.
,, 10. Ibid., cephalon. Same form. and loc. × 4. Mr. J. G. Hamling's coll.
,, 11. Ibid., entire specimen. Same form. and loc. × 4. Mr. Coomáraswámy's coll.
,, 12. *Proetus*, sp., pygidium. Same form.: Hannaford Quarry. Nat size. Mr. Coomáraswámy's coll.
,, 13. *Phillipsia Polleni* (?), free cheek. Same form., loc., and coll. × 1½.
,, 14. *Griffithides Barkei*, sp. nov. Culm-measures (?): Bishopston, Glamorganshire. × 3. Mr. F. Barke's collection.
,, 15. Ibid., hypostome. Same form., loc., and coll. × 3.

II.—*Eophrynus* and Allied Carboniferous Arachnida.

By R. I. Pocock, F.Z.S., of the British Museum (Natural History).

(*Concluded from p.* 448.)

Part II.

2. Classification of *Eophrynus* and its Allies.

Several Arachnida allied to *Eophrynus prestvicii* have been discovered in beds of Carboniferous age. Of these the only species known to me as belonging unquestionably to the genus *Eophrynus* that has been properly described and figured is the form from Silesia named *Eophrynus* (in error written *Euphrynus*) *salmi* by Stur.[1] The type is 27 mm. in total length, the prosoma being 8 long and the opisthosoma 19 long and 14 wide. The last-named region is thus considerably narrower in relation to its length than it is in *E. prestvicii*. Apart from this, it is noticeable that the admedian dorsal tubercles, except on the second and third terga, are much smaller than the laterals.

Haase[2] has characterized a third species of *Eophrynus* as *E. sturi*. It is said to be intermediate between *E. prestvicii* and *E. salmi* in having the joints of the lateral tergal laminæ less distinct than in the latter, and more distinct than in the former. Haase's knowledge of *E. prestvicii*, however, was derived from the figure of the type from which the artist omitted the sulci in question. As already described, they are well developed. Hence any inference that is based upon their assumed absence is erroneous. It seems probable that the degree of their distinctness in any given case is more likely to be attributable to the state of preservation of the fossil than to a natural structural variation. Lastly, it appears to me that before the specific distinctness of the three forms that

[1] Abh. k.k. geol. Reich., vol. viii (1877), pt. 2, Vorwort, p. v, with figure.
[2] Zeitschr. deutsch. geol. Ges., vol. xlii (1890), p. 64.

have been described as *prestvicii*, *salmi*, and *sturi* be unreservedly admitted, the type-specimens must be carefully compared together.

Another species that has been assigned to the genus *Eophrynus* is the form that was described by Dr. Woodward as *Brachypyge carbonis*, the principal synonymy of which is as follows :—

Brachypyge carbonis, Woodw.

Brachypyge carbonis, H. Woodw.: Geol. Mag., Dec. II, Vol. V (1878), pp. 433–6, Pl. XI ; id., Bull. Acad. Belg. (2), vol. xlv (1878), No. 4, pp. 410–415, with plate.

Anthracomartus carbonis, Scudder: C.R. Soc. Ent. Belg., vol. xxix (1885), pp. 84–85.

Eophrynus carbonis, H. Woodw.: Geol. Mag., Dec. III, Vol. IV (1887), p. 49 (footnote) ; Q.J.G.S., vol. lii (1896), p. cix.

This species is represented by eight somites of the opisthosoma, exposed from the dorsal side. The possibility of the correspondence of these to the nine tergal plates of *Eophrynus prestvicii* by the complete fusion of the original second and third to constitute the large second tergal plate of the fossil, has been already discussed (cf. *supra*, Pt. I, p. 444). The somites have the same general form and structure as in *Eophrynus*, *Kreischeria*, and *Anthracomartus*, but differ markedly in that the edges of the lateral laminæ are emarginate with projecting anterior and posterior angles. This structural modification gives rise to the characteristically scalloped appearance of the borders of the opisthosoma. The latter is wider than long; its central area is raised into an axial elevation due to the development of a bilobed excrescence on each of the terga, that of the second being exceptionally large and recalling the tubercular eminence on the third tergal plate of *Eophrynus prestvicii*. No lateral laminæ are present upon the first or second plates, which were themselves possibly fused ; and the last tergum visible on the dorsal side is exceptionally large as compared with the homologous plate in *Eophrynus prestvicii*.

Nearly allied to but apparently quite distinct from the foregoing species is the following, to which I am compelled to give a new name :

Brachypyge celtica, sp.n.

Eophrynus carbonis, Howard & Thomas : Trans. Cardiff Nat. Hist. Soc., vol. xxviii (1896), pt. 1, pp. 1–2, figs. A and C. (*Nec* Woodward.)

This species is also represented only by the opisthosoma; but although the ventral surface instead of the dorsal is exposed, it presents three characteristics in which it differs markedly from the opisthosoma of *B. carbonis*, Woodw. In the first place it is much wider than long, in the second place the second somite is considerably wider than the first, and in the third place both the first and second somites are furnished with lateral laminæ similar in form to those of the somites that follow.

It consists of nine somites, in addition to the anal valve. The first and second show very distinctly the impression of the missing coxa and trochanter of the last appendages of the prosoma, which were overlapped by their laterally expanded dorsal area. There is an angular depression in the middle of the posterior half of the sixth

and seventh, and a narrow transverse depression, identified by the describers as a stigma, on the posterior border of the lateral portion of the third, fourth, fifth, sixth, and seventh somites. The lateral laminæ and the sides of the last somite are conspicuously pitted.

The type-specimen of *Brachypyge carbonis* was originally described, in 1878, by Dr. Woodward as the abdomen of a Brachyurous Decapod Crustacean, to which in a general way it certainly bears a resemblance. Geinitz, and independently Scudder, were the first to suggest its probable Arachnid nature. This suggestion was subsequently adopted by Dr. Woodward.[1] Haase, however, who in 1896 published his critical revision of the Carboniferous Arachnida, rejected the later view, and, readopting in substance Dr. Woodward's original supposition, held the specimen to be the abdomen of an Anomurous Crustacean allied to *Lithodes*. That Geinitz and Scudder were right, is shown, I think, by the discovery by Howard & Thomas of the species here named *Brachypyge celtica*, which is certainly referable to the same section of the animal kingdom as *Anthracomartus* and *Eophrynus*, and at the same time shows great similarity to *B. carbonis*.

The fossil described as *Kreischeria wiedei* by Geinitz[2] is obviously nearly related to *Eophrynus*, as has been insisted upon by Scudder[3] and Haase.

Although the tubercles are fewer in number and restricted to the median portion of the terga, the opisthosoma is in a general way practically identical structurally with that of *Eophrynus*, even to the presence of a spiniform process upon the posterior angle of the lateral lamina of the seventh and eighth terga. The question of the homology of the anterior terga has been already discussed. It may be added, however, that although the second tergum is longer than the first or third, its median tubercles are absent instead of enlarged as in the third tergum of *Eophrynus*. The carapace, too, is very similar to that of *Eophrynus*, though less corrugated. Its median area is elevated, and its lateral area transversely grooved and horizontal. There is this difference, however, between the two. In *Kreischeria* the posterior horizontal area is considerably longer than in *Eophrynus*; the central fovea extends forwards as a long and deep groove past the middle of the elevated area, which is sharply constricted in its anterior portion. The area in front of the constriction is about as wide as long, and bears a pair of large eyes in its centre. Movably attached to its fore margin, there is said by Haase to be a separate transverse skeletal piece. The presence of this frontal sclerite in *Kreischeria* and its apparent absence in *Eophrynus* were the main characters upon which Haase relied in referring these genera to different families, the Kreischeriidæ and Eophrynidæ. Considering, however, how closely related the two are in other respects, I cannot, without further evidence, believe in the reality of this difference,

[1] See H. Woodward, Presidential Address to the Geological Society, 1896, vol. lii, p. cix.

[2] Zeitschr. deutsch. geol. Ges., vol. xxxiv (1882), p. 238, pl. xiv.

[3] Proc. Amer. Acad. Arts and Sci., vol. xx (1885), p. 17.

and must hold that if this frontal plate was present in *Kreischeria* it was also present in *Eophrynus*; and, conversely, if it was absent in *Eophrynus*, as appears to be the case, Haase probably put a wrong interpretation upon the structure he described as a separate 'Stirnschild.' In short, I see no reason for dissenting from Scudder's view that the two genera belong to one and the same family.

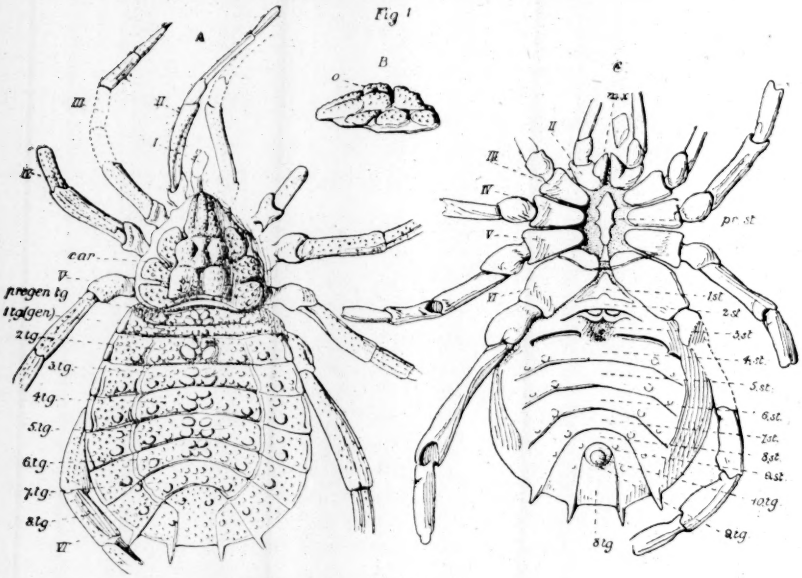


FIG. 1.

A.—Dorsal surface of *Eophrynus prestvicii*. I–VI, appendages of the prosoma; *car.* carapace; *pregen. tg.* tergum of pregenital segment; 1 *tg.* (*gen.*) tergum of first or genital segment of opisthosoma; 2 *tg.*–7 *tg.* terga of second, seventh, and intervening segments with movable lateral laminæ; 8 *tg.* tergum of eighth segment with movable lateral laminæ and immovable posterior median lamina.

B.—Lateral view of carapace, the anterior extremity to the left, the posterior to the right. *o.* 'ocular' pit on the median lobe.

C.—Ventral surface. II–VI, coxal segments of the post-oral appendages of the prosoma, those of the second pair (palpi) bearing the maxillary process (*mx.*); *pr. st.* sternal area of prosoma with median sternal plates and lateral membranous area; 1 *st.* sternal plate of first or genital segment of opisthosoma; 2 *st.* ditto of the second segment, with paired lobes; 3 *st.* ditto of third segment, with median depression and laterally elevated posterior border; 4 *st.*–8 *st.* ditto of the fourth, eighth, and intervening segments, with paired tubercles; 9 *st.* ditto of the ninth or pre-anal segment; 8 *tg.* lower surface of median lamina of tergum of eighth segment; 9 *tg.* tergal area of ninth segment; 10 *tg.* anal operculum or tergal plate of the tenth segment.

Provisionally, at all events, I think *Brachypyge* may be allowed to stand as a distinct genus. It has been dropped as a synonym both of *Eophrynus* and *Anthracomartus*, without the certainty of its identity with either. Indeed, until the structure of the prosoma is known, the genus cannot with assurance be referred either to

the Eophrynidæ or Anthracomartidæ. The two species here assigned to it resemble each other, and differ from the known forms of the other genera in certain characters of which the value cannot accurately be assessed on account of scarcity of material wherewith to test their constancy. Pending the discovery of this desirable addition to our knowledge, it is a matter of indifference whether we classify *Brachypyge* with the Anthracomartidæ or Eophrynidæ.

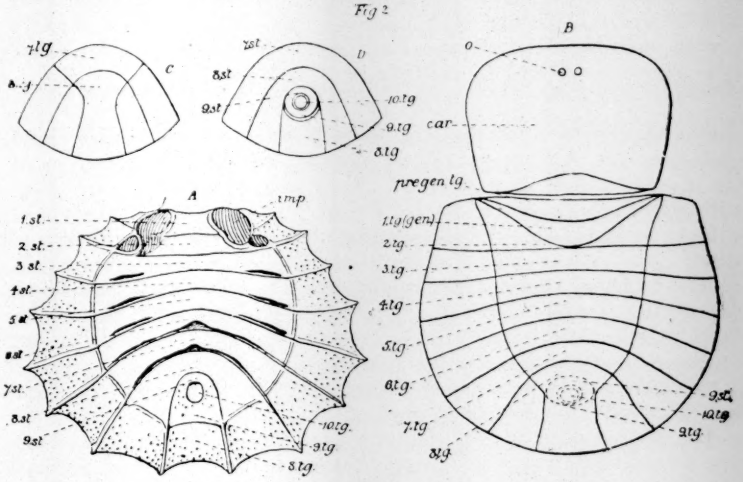


FIG. 2.

A.—Ventral view of opisthosoma of *Brachypyge celtica* (after Howard & Thomas), with lettering as in Fig. 1, *C*, with the addition of *imp.*, marking the impression of the coxa of the sixth appendage.

B. — Dorsal view of *Anthracomartus palatinus*, after Ammon. *car.* carapace; *o.* eyes. Lettering of the opisthosoma as in Fig. 1, *A* and *C*, the segments marked 9 *tg.*, 10 *tg.*, and 9 *st.* indicated by dotted lines to show their position beneath the eighth segment with its lateral movable and median immovable laminæ (8 *tg.*).

C, *D.*—Dorsal and ventral views of posterior end of opisthosoma of *Anthracomartus völkelianus*, Karsch (after Haase). Lettering as in the foregoing figures.

The following table will perhaps, as well as another, represent the affinities of the genera:—

a. Carapace with its dorsal area flattish or evenly convex from side to side, undifferentiated into a median elevated and a lateral horizontal area, and without strongly marked median and lateral muscular impressions.
Fam. ANTHRACOMARTIDÆ.

a[1]. Free edges of the lateral tergal laminæ of the opisthosoma concave, with projecting spiniform angles ... ... *Brachypyge*, Woodw.

b[1]. Free edges of the lateral tergal laminæ evenly convex, forming a continuous curve ... ... *Anthracomartus*, Karsch.

b. Carapace with its dorsal surface differentiated into a median elevated area and a horizontal lateral area; the median and lateral muscular impressions deep; edges of tergal laminæ of opisthosoma convex as in *Anthracomartus*, but the posterior angles of the seventh and eighth spiniform ... Fam. EOPHRYNIDÆ.

a^2. Carapace with its posterior horizontal area short, the median muscular fovea forming an angular notch in the posterior border of the elevated area. *Eophrynus*, Woodw.

b^2. Carapace with its posterior horizontal area relatively long, the median muscular fovea forming a deep longitudinal groove extending forwards past the middle of the median elevation ... ... *Kreischeria*, Gein.

With the genus *Anthracomartus* it is needless here to deal. So far as I know, it chiefly differs from *Eophrynus* and *Kreischeria* in the structure of the carapace, which, instead of being mesially elevated and laterally horizontal and grooved, has a flattened or slightly convex undifferentiated dorsal surface. A pair of small median eyes has been detected by Ammon in *A. palatinus*.

3. Taxonomy of the Anthracomarti.

Of the various attempts that have been made to classify these Carboniferous Arachnida and to give them their true position in the class to which they belong, Haase's is unquestionably the most successful.

Scudder included such heterogeneous elements under the Anthracomarti that no satisfactory definition of the order was possible. Moreover, he severed *Anthracomartus* from *Eophrynus* and *Kreischeria*, classifying it with *Geraphrynus* and *Architarbus* under the Architarbidæ, and thus failed in his diagnosis of both families. Haase, on the contrary, recognized the close relationship between *Eophrynus*, *Kreischeria*, and *Anthracomartus*, and rightly restricted the term Anthracomarti to these three genera.

His appreciation also of the affinities between the Anthracomarti and recent Opiliones was a great advance in the taxonomy of fossil Arachnida. It may be doubted, however, whether his classification of the Opiliones into the four suborders Phalangiotarbi, Anthracomarti, Laniatores, and Palpatores is one that represents in a true light the affinities between the forms included. On the position of Phalangiotarbi I do not wish to give an opinion until an examination of the fossil is possible; but it seems to me that what we now know of the Anthracomarti justifies the conclusion that *if* this group be included in the Opiliones it must be given a rank equivalent to the Laniatores, Palpatores, and Anepignathi or Cyphophthalmi—the Opiliones veri—taken together. These three suborders are distinguished by the sum of a number of characters, many of which, such as the armature of the palpi, the numbers of claws on the legs, etc., admit of exceptions, and no one of which is perhaps in itself of subordinal value. On the other hand, they resemble each other and differ from the Anthracomarti in certain structural features of sufficient taxonomic importance to admit of their association in one group, which may be termed the Phalangiomorphæ, equivalent to the Anthracomarti.

The two may be distinguished as follows:—

a. The prosoma and opisthosoma not immovably welded together, but freely articulated to one another, as in all the primitive types of Arachnida. The segments of the opisthosoma also apparently jointed by flexible arthrodial membrane. The lateral margins of the terga produced into large laminæ, secondarily divided by a joint-forming sulcus from the central portion of the somite. Basal segments

of the third, fourth, and fifth pairs of appendages movable and separated by a wide sternal area, which was membranous at the sides and furnished with a median longitudinal sternal plate, extending anteriorly between the coxæ of the appendages of the third pair (first pair of walking-legs).

ANTHRACOMARTI.

b. Prosoma and opisthosoma not movably jointed together, and at least the anterior four somites of the opisthosoma fused. Lateral portions of terga and sterna of opisthosoma not produced into movably jointed laminæ. Coxæ of the posterior appendages free or united to the prosoma, the sternal region of which is reduced to a narrow longitudinal sclerite by the encroachment of the appendages towards the middle line, or to a short transverse plate by the forward movement of the sternal elements of the anterior somites of the opisthosoma ... ... PHALANGIOMORPHÆ.

But whether the definition of the Opiliones be extended to include the Anthracomarti or whether the latter be regarded as an order apart, are questions of subordinate importance. The chief interest attached to these Carboniferous Arachnida lies in the fact that, setting aside the development of the specialized tergal laminæ, the characters in which they differ from the Opiliones serve to link the latter to the Pedipalpi. The fusion of the prosoma with the opisthosoma, and of more or fewer of the tergal plates of the latter region with each other; the reduction in number of the segments of the opisthosoma to ten, including the anal valve, or eight; the immobility of the coxæ of the appendages and their admedian approximation on the lower side of the prosoma, accompanied by the reduction in size of the sternal sclerite, are a few of the many specialized features of the Opiliones. But since the Arachnida of this order are descended from forms in which the opisthosoma consisted of twelve separately jointed segments and was movably articulated to the prosoma, and in which the appendages of this region were freely movable and were separated by a broad sternal area furnished with a large sternal plate or plates, the existence of forms antecedent to the Opiliones and occupying an intermediate position between them and the primitive type is a necessity demanded by the theory of descent. The nearest known allies to these antecedent forms are, I believe, the extinct Arachnida belonging to the Carboniferous Anthracomarti.

III. — The Basalt of the Moabite Stone.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

A BLOCK of basalt, bearing an ancient inscription in a Semitic language, was discovered in 1868 at Dhiban (the Dibon of Scripture) by the Rev. F. A. Klein, of the Jerusalem Mission Society. This block, which measured 3′ 10″ × 2′ 0″ × 1′ 2·5″, proved on examination to have been erected by Mesha, King of Moab about 890 B.C., and to refer to the war mentioned in 2 Kings iii. A series of blunders on the part of those anxious to obtain this interesting relic caused a quarrel about ownership between two Arab tribes, and one of them, to spite the other, broke it in pieces. These, however, were obtained by the French Consul in Palestine, and sent to Paris, where they were fitted together so far as possible, and the

repaired stone is now in the Louvre Museum.[1] The late Professor E. H. Palmer, on a visit to Dhiban in 1870, picked up a small fragment from those still lying on the spot, which he gave to me on his return to England. The constant pressure of other work has hitherto prevented me from examining the specimen, and I have only recently had a slice prepared. The largest face of the fragment measures about 3″ × 2·5″, but the thickest part hardly exceeds half an inch. The original smoothed surface of the stone, possibly including part of a letter, may be seen on one of the sloping sides.

The rock apparently is in good preservation; minutely granular, nearly black in colour, but proving on a closer examination to be speckled with more than one dark mineral, and with less definite greyish spots, all very small. Its specific gravity (by a Walker's balance) is 2·89. The slice, when examined under the microscope, exhibits a porphyritic structure, though on a small scale, no one of the minerals exceeding about ·05″ in diameter. They are:—(*a*) Augite, not abundant, brown in colour, the grains presenting a rather corroded aspect both externally and even internally, partially including, in one instance, a small grain of the next mineral. (*b*) Olivine, rather abundant, rounded or slightly irregular in outline, occasionally showing a fairly well-developed brachypinacoidal and an imperfect macropinacoidal cleavage. A brown staining has affected the exterior of most grains, and penetrated for a short distance into cracks. This, in addition to a very faint yellowish tinge in the grains, shows the olivine to be a rather ferriferous variety. (*c*) Iron-oxide, hematite, or perhaps ilmenite, with a rusty-looking exterior; (*d*) felspar: this, like the last-named mineral, varies so much in size that it is difficult to draw the line between crystals occurring porphyritically and those in the base. In no case do the extinction angles give very decisive evidence, but they suggest that labradorite is at any rate the dominant species.

The minutely holocrystalline groundmass, except for one or two small patches, consists of lath-like plagioclases, up to about ·004″ in length; of stumpy, not very well-formed prisms of brown augite, about ·002″, and of granules of iron-oxide. The patches, small[2] and not numerous, are formed by a fairly clear mineral, which, however, includes some very minute films, giving bright polarization tints, its own being very low, not rising above a greyish or slightly pinkish white. Each patch generally consists of two or three grains, and is without a definite external form. The small felspars and augites are sometimes included by or project into these patches from the surrounding matrix, which has no regular boundary. The mineral resembles a lime carbonate (there is no distinct cleavage), and I observed, on applying some hydrochloric acid to the cut surface, a rather brisk effervescence at a number of points; hence, I conclude it must be calcite, probably not very pure. But though it occurs

[1] Palmer: "Desert of the Exodus," pt. 2, ch. x. For the inscription see Ginsburg, "Moabite Stone." A figure and succinct account are given in Chambers' Encyclopædia, s.v. Moabite Stone.

[2] The diameter of the largest is about ·03″.

sporadically it does not seem to fill a cavity, or to have replaced a less stable species of felspar, which indeed, as the rock is in good preservation, is hardly probable. So I think the mineral must have been present as a constituent when the rock was molten, and can only suppose that the latter, on its ascent to the surface, caught up some intervening limestone, and the pressure sufficed, as in a case of contact metamorphism, to prevent the dissociation of the carbonate, which here and there retained its identity in the viscid mass.[1] This occurrence in such a rock as basalt, is, I think, rather unusual.

IV.—The Cenomanian Overlap.

By A. J. Jukes-Browne, B.A., F.G.S.

THAT the Upper Cretaceous deposits overlap those of the Lower Cretaceous series, and extend over much larger areas throughout the whole of western and central Europe, are facts which have long been familiar to all European geologists. There has, however, been a tendency, especially in France, to imagine that the subsidence to which the overlap is due took place at one particular epoch, namely, the Cenomanian, and that this subsidence was so rapid and profound that it caused the Upper Cretaceous Series to be sharply marked off from the subjacent strata by the so-called 'Cenomanian transgression.'

Moreover, some French geologists so magnified the importance of this transgression that they regarded it as a criterion for deciding whether a given stage or zone should be classified as Lower or Upper Cretaceous. Their views have doubtless had much influence upon Continental opinion, and are largely responsible for the classification which places the 'Albian' in the Lower Cretaceous Series, and for the uncertainty as to whether the zone of *Am.* (*Schlœnbachia*) *rostratus* should be grouped with the Albian or the Cenomanian.

In England there has never been any such doubt; we have always included the Gault (Albian) in the Upper Cretaceous Series, and have regarded it as partaking in the transgression of that series beyond the limits of the Vectian or Lower Greensand.

The French view dates from the time of D'Orbigny, who wrote in 1840 as follows:—"From the time of the craie chloritée (which he afterwards called Cenomanien) we see that the whole aspect of the Cretaceous seas was changed. . . . At about this epoch the extension of the seas both in France and throughout Europe was at least double that which they had at the time of their first invasion of the region in the Neocomian period." This generalization may have been in accordance with the knowledge of D'Orbigny's time, but is not maintainable in the light of more recent investigations. It should be remembered that when D'Orbigny thus wrote, and for many years afterwards, he believed that there was a marked discordance between the Albian and the Cenomanian deposits, and that

[1] For cases of the imperfect digestion of a carbonate in an igneous mass, see J. Parkinson, Q.J.G.S., lvii (1901), p. 198, and A. K. Coomáraswámy, id., lviii (1902), p. 399.

no representative of the former existed on the coast of Normandy nor in the departments of Orne or Sarthe. We now know that there is no such discordance, only an overlap, and that the Albian (both as Gault and Gaize) occurs in Normandy as well as in the Orne.

It is therefore satisfactory to find that some French geologists are beginning to see that the Cenomanian transgression was only part of a general Cretaceous transgression, which was due to a great and continued subsidence, and not to a specially extensive subsidence at the beginning of Cenomanian time. M. de Grossouvre, in a paper read at the meeting of the French Association for the Advancement of Science in 1901, has protested against the accepted view of the 'Cenomanian transgression,' and his remarks are so decisive that they deserve a larger audience than that to which they were specially addressed. From them I quote the following translated paragraphs:—

"To begin with, it is essential to point out that this transgression was not a sudden and almost instantaneous phenomenon, and that on this account it cannot be considered as a disturbance of a definite date furnishing everywhere a clearly-marked point of departure.

"Let us examine, for example, what happened in the northern and central parts of Europe. We know that large areas were raised into land toward the close of Jurassic time; then with the opening of the Lower Cretaceous era we perceive the sea advancing from the Mediterranean region to invade by degrees the territories which it had temporarily abandoned. In one place it is the *Spatangus* limestones (Neocomian) which rest on the Jurassic; in another it is the sands with *Am. Milleti*, or the clays of the zone of *Am. mammillaris*; elsewhere it is the zone of *Am. inflatus* which commences the transgressive series.

"This slow and continued progress of the invasion of the continental area by the sea is observable not only in northern and central Europe, but can be traced in nearly every part of the globe. . . . [References are here given to the transgression in North America, Brazil, and West Africa.]

"I content myself with these few examples, which it would be easy to multiply, and from the above statements I think I may safely draw the conclusion, that the Cenomanian transgression represents only one phase or episode in a long period of slow and continued transmutation, which can be followed from the very dawn of the Cretaceous era. Moreover, the movement did not stop with the Cenomanian epoch, and I could show that it was continued up to the end of Campanian time (Upper Senonian).

"It has been said that at the epoch of the *Am. inflatus* beds it was so pronounced that it constitutes by this very circumstance an exact chronological datum which can everywhere be recognized. This in my opinion is another mistake, for if at many points the beds with *Am. inflatus* are seen in transgression over the older deposits, in many other places we can see the free Cenomanian resting directly on the Jurassic and sometimes on the Primary rocks. Is it not so at Mans, where D'Orbigny took the type of his stage? In Aquitaine, at Essen in Westphalia, in Bavaria, in Saxony, Bohemia, Galicia,

and over the greater part of the Russian platform, the base of the overlapping Cenomanian does not show any trace of the beds with *Am. inflatus*."

By the "free Cenomanian" he clearly means the upper or true Cenomanian, free from the zone of *Am. rostratus* (*inflatus*); the zone of *Am. varians* having overlapped that of *Am. rostratus*, just as the latter has overlapped the Lower Gault with its zones of *Am. interruptus* and *Am. mammillaris*. He concludes by showing that the generality of the special Cenomanian transgression has been much exaggerated; that Cenomanian deposits are absent in some parts of France, Switzerland, Spain, North Africa, and America; and that subsidence of one region has generally been compensated by the upheaval of some neighbouring region.

We may hope that this vigorous protest will go far toward dispelling the false conception of a special Cenomanian subsidence and transgression which has so long been one of the fixed opinions of Continental geologists. The transgression exists, but should be described as the Cretaceous, not the Cenomanian, transgression.

It may well be that the extent of surface gained by the sea of the Cenomanian or Lower Chalk age in Europe was greater than that gained during any previous stage of the Cretaceous period, but the extent of such an invasion of the sea depends not only on the amount of vertical subsidence but also on the slope of the area invaded; thus a subsidence which would carry the sea only 20 yards up a steep slope might carry it 20 miles over a fairly level plain. It is therefore very probable that those regions where Cenomanian deposits form the basement-beds of the Cretaceous Series over a large extent of country were broad terrestrial plains during the formation of the earlier Cretaceous strata; and that the subsidence which carried the sea over them was not more rapid nor vertically greater than the subsidence which occurred in the preceding Selbornian stage or in that of the succeeding Turonian.

V.—Notes on the Fossils of the Silurian Area of North-East Ireland.[1]

By R. Clark, Esq.

It would be difficult after the closest investigation to add much to the exhaustive list of species given in the excellent paper on this subject which was read by Mr. Swanston before the Belfast Naturalists Field Club some twenty-five years ago. In that paper reference is made to the classification by the Geological Survey of the rocks of the district, under the general heading of Lower Silurian. Subsequently to the publication of the maps of the area, the information as to the Silurian fauna was greatly extended by the labours of Professor Lapworth and Mr. Swanston, to whom science is so largely indebted. The

[1] Read before the British Association, Belfast, Sept. 1902, in Section C (Geology). Communicated by permission of the Director of the Geological Survey.

completion of the *one-inch* Geological Map of Ireland enabled the revision of work done in the earlier stages of the Survey's existence to be undertaken, and in this revision the North-East Silurians were amongst the first dealt with, and I was detailed to search the most promising localities for fossils, and to zone the beds in which they might occur.

This work was proceeded with until not only the North-East area but the Southern Silurian districts also were gone over; and a comparison of the old series of maps and the revised editions which have been published within the past few years will show that the results of the collections made have necessitated very considerable alterations in the original mapping.

Taking Coalpit Bay, Donaghadee, as a starting-point, this prolific though circumscribed little area, afforded a key to the vast proportion of the Silurian beds which with slight interruption extend southwards to the Atlantic on the Waterford coast; and although in few other localities was the same wealth of fauna of different horizons met with, it was interesting to recognize in numerous new localities the occurrence of forms which enabled a ready recognition of the exact position of the beds, most of which were typically represented in the regular sequence of Coalpit Bay.

As some time must elapse before revised explanations to the new editions of the maps will be forthcoming, brief notices of new or hitherto unrecorded species, gaps filled up, and new localities may be interesting and useful.

In the district covered by Mr. Swanston's paper it will be sufficient to mention a couple of localities, new or hitherto unreferred to. First I would mention a section cut through by a small stream at Lissan, near Saintfield (Sheet 37), from which a number of specimens indicative of Lower Hartfell (Caradoc) beds were obtained; these were mostly in a state of excellent preservation, and amongst other species were the following:—

Diplograptus foliaceus.
" *mucronatus.*
" *truncatus.*
Climacograptus Scharenbergi.
Leptograptus flaccidus.
Pleurograptus linearis.
Glossograptus Hincksii.
Dicellograptus elegans.
" *Forchammeri.*
" *Morrissi.*
" *Moffatensis.*
Dicranograptus ramosus.
Corynoides calcularis.
Siphonotreta micula.

The second locality is a small quarry in Holywood Glen (Sheet 29), which yielded a number of species characterizing this locality as the Glenkiln horizon (Upper Llandeilo); principal amongst the forms which occur here in easily recognizable condition being—

Cœnograptus gracilis.
" *circularis.*
" *pertenuis.*
Thamnograptus typhus.
Glossograptus Hincksii.
Climacograptus Scharenbergi.
Climacograptus bicornis.
Dicellograptus intortus.
" *sextans.*
" *Moffatensis.*
Dicranograptus ramosus.

The absence of *Rastrites maximus*, *Dicellograptus anceps*, and *Pleurograptus linearis* having been commented on by Messrs. Swanston and Lapworth, it is satisfactory to record that I have since found these forms, the first-named at Tieveshilly, the second in a pocket of black slate in greenish mudstone at Coalpit Bay, whilst *Pleurograptus linearis* was collected from the locality at Lissan previously referred to.

A unique specimen from the Lower Birkhill (Llandovery) beds of Coalpit Bay claims attention. It has been identified by Mr. E. T. Newton, F.R.S., as *Berwynia Carruthersi*, a Lycopodiaceous plant, originally described by Dr. Hicks from Pen-y-glog (Q.J.G.S., vol. xxxviii) ; it had not hitherto been recognized in Ireland.

Passing from what may be styled the Belfast immediate area towards the south and south-west, some ten additional fossiliferous localities were added to those already recorded. From the district comprised within Sheet 48, they were, with one exception, all indicative of the Middle or Lower Birkhill (Llandovery) horizon, and, save from one locality, Lough Erne, on the north-east margin, which yielded eight species of Graptolitidæ, the specimens obtained were not well preserved.

The Armagh district (Sheet 47) afforded good and interesting collecting ground, though no fossils from the Silurian beds appear to have been previously recorded. A close examination disclosed numerous localities in both upper and lower strata, ranging from Lower Llandovery to Upper Llandeilo, this latter zone being well represented a little north of Poyntzpass by the occurrence of—

Dicellograptus Moffatensis.
,, *sextans.*
,, *Forchammeri.*
,, *truncatus.*
Didymograptus superstes.
Dicranograptus ziczac.
Diplograptus bimucronatus.
Cœnograptus gracilis.
Climacograptus Scharenbergi.
Siphonotreta micula.

These forms were found in the black carbonaceous, cherty band generally associated with this particular horizon.

Within the radius of Sheets 58 and 59, more especially in the north-east corner of the latter, finely preserved specimens of Upper Llandovery Graptolites were found in the railway cuttings close to the tunnel on the Newry and Armagh Railway, whilst in the vicinity of Castleblayney both Llandovery and Caradoc specimens occur in numerous places. In Sheet 58 *Cœnograptus gracilis* was noted in the railway cutting east of Newbliss, indicating Upper Llandeilo.

Sheet 69 afforded substantial additions to the list already published therefrom. Graptolites were procured from some twelve additional localities, and from many of these the specimens were obtained in excellent preservation ; in this respect those from Killyrue, four miles south-east of Cootehill, are specially worthy of mention.

The known localities for Silurian fossils on Sheet 80 have been much increased, and good specimens obtained of Lower Caradoc and Llandovery species ; of the former *Diplograptus foliaceus*,

Dicellograptus, and *Pleurograptus* were indicative, whilst the higher zone is distinguished by such as *Monograptus convolutus* and *M. tenuis*, as also *Diplograptus folium*, or *palmeus*, which is somewhat rare outside the Coalpit Bay district.

The fossils of the Silurian rocks of Sheet 81 are dealt with rather fully in the memoirs of that and the adjoining Sheet 91, in which latter the district of Slane afforded a rich harvest of forms ranging from Llandeilo to Wenlock. Sheet 82 had been hitherto regarded as a barren area so far as fossils were concerned; however, a close search disclosed at a couple of localities near Clogher Head the existence of the zone of *Monograptus exiguus*, or top of Upper Llandovery, and in addition to *M. exiguus* beautifully preserved specimens of *Monograptus attenuatus, crispus, proteus*, and *lobiferus* were procured; indeed, at no other locality save Tieveshilly were the same peculiar forms observed.

VI.—A (Preliminary) List of the Minerals occurring in Ireland.[1]

By Henry J. Seymour, B.A., F.G.S.

THE literature dealing with Irish mineralogy is rather extensive, much more so than might be at first thought, but it is of such a scattered nature that to obtain at present anything like a complete account of the minerals which occur in this country, or in any particular portion of it, would involve much time and labour in hunting up the publications containing the various records. The need of some authentic work of reference on the subject, revised to date, was often felt by the writer, who some years ago set to work to collect together all the data available, both from published records and by means of a personal examination of such public and private collections of minerals in this country as he could gain access to.

This research is not yet complete, but the publication last year of a list of Scottish minerals at the British Association meeting in Glasgow has induced the writer, in view of the meeting of the same Association in Belfast this year, to publish a *preliminary* list of Irish minerals. This list comprises the various species which up to the present he is satisfied may be regarded as undoubtedly occurring in Ireland. References were made to the lists of Irish minerals which have already been published, the last in 1868. These have appeared as appendices to lists from other localities, and in publications now out of print. G. H. Kinahan's publication (Economic Geol. of Ireland) dealt solely with metallic ores and a few other economic minerals. In the account which the writer hopes to have ready for publication within a year, the occurrence of Irish minerals only will be mentioned, together with other important details of interest, and

[1] Abstract of a paper read before the British Association, Belfast, September, 1902, in Section C (Geology).

accompanied by analyses when obtainable. It is also contemplated to add a Bibliography of Irish Mineralogy. In the above respects it will therefore be the first publication of its kind in this country; and the chief aims of its compiler are: to encourage the study of a much neglected science in Ireland; to prevent the possibility of anyone announcing as 'new finds' minerals recorded more than twenty years ago, instances of which have come to the notice of the writer in the course of his work; and to prevent the waste of energy involved in re-examining well-known localities, to the neglect of others much more promising and quite unworked.

The following is the preliminary list of Irish minerals above referred to; and the further work which the writer hopes to do during the coming year will doubtless add many more species to the list, and perhaps also lead to the removal of a few which now find a place therein.

Graphite.
Sulphur.
Gold.
Silver.
Copper.
Stibnite.
Molybdenite.
Galena.
Chalcosite.
Blende.
Pyrrhotite.
Bornite.
Chalcopyrite.
Pyrites.
Cobaltite.
Marcasite.
Arsenopyrite.
Tetrahedrite.
Geocronite.
Halite.
Fluor.
Quartz.
Tridymite.
Opal.
Water.
Cuprite.
Corundum.
Hæmatite.
Ilmenite.
Magnetite.
Cassiterite.
Rutile.
Octahedrite.
Brookite.
Pyrolusite.
Manganite.
Limonite.
Bauxite.

Psilomelane.
Calcite.
Dolomite.
Siderite.
Smithsonite.
Aragonite.
Cerussite.
Malachite.
Azurite.
Orthoclase.
Microcline.
Anorthoclase.
Albite.
Oligoclase.
Andesine.
Labradorite.
Anorthite.
Enstatite.
Hypersthene.
Augite.
Spodumene.
Wollastonite.
Rhodonite.
Hornblende.
Arfvedsonite.
Beryl.
Iolite.
Garnet.
Olivine.
Fayalite.
Idocrase.
Zircon.
Topaz.
Andalusite.
Sillimanite.
Kyanite.
Gadolinite.
Zoisite.

Epidote.
Axinite.
Calamine.
Tourmaline.
Staurolite.
Apophyllite.
Heulandite.
Epistilbite.
Phillipsite.
Harmotome.
Stilbite.
Laumonite.
Chabazite.
Gmelinite.
Levyne.
Analcime.
Natrolite.
Mesolite.
Thomsonite.
Muscovite.
Biotite.
Lepidomelane.
Serpentine.
Talc.
Glauconite.
Kaolinite.
Pyrophyllite.
Sphene.
Apatite.
Pyromorphite.
Vivianite.
Erythrite.
Wavellite.
Beudantite.
Barytes.
Anglesite.
Gypsum.
Amber.

VII.—The Canadian Rockies. Part I: On a Collection of Middle Cambrian Fossils obtained by Edward Whymper, Esq., F.R.G.S., from Mount Stephen, British Columbia.[1]

By Henry Woodward, LL.D., F.R.S., F.G.S.

In the Summer of 1901 my friend Mr. Edward Whymper, the well-known traveller, mountain explorer, and writer, paid a visit to the watershed of the Canadian Rocky Mountains, and during a stay at Field, the highest pass reached on the Canadian and Pacific Railroad, he examined the slopes of Mount Stephen, and at a height of 6,000 feet on its northern side found numerous Trilobites, and brought home a considerable collection.

These fossils have been most obligingly placed in my hands by Mr. Whymper, and, although previously known, they have not all been adequately figured. I venture to think their illustration may be useful, accompanied by some further notes on the fossils associated with them.[2]

Locality.—Two mountain peaks, Mount Field (5,000 feet) on the right bank and Mount Stephen (8,000 feet) on the left bank of the Wapta or Kicking Horse River, stand as flanking bastions to the valley, whose base is about 4,500 feet above sea-level, and some miles to the east of which is the 'Great Divide,' the water-parting of the 'Rockies,' where the primitive sources of the mountain streams separate, the waters of the western side to join the Columbia River and the Fraser, and ultimately flowing to the Pacific, while those of the eastern side add their various contributions to the Bow River, which finally empties itself into Hudson's Bay.

The 'Rockies,' which run in a north-west and south-east direction, taken in their widest extent of lateral buttresses, may, speaking broadly, be said to embrace the Coast Range on the west, which is followed by the Gold Range, the Selkirks, *the Rocky Mountains proper*; then follow to the east the Foot Hills, giving place to the vast rolling Prairies beyond.

The earliest record of the discovery of fossils on Mount Stephen is that of Mr. L. M. Lambe, one of the Surveyors on the staff of the Canadian and Pacific Railway in 1884. (Mr. Lambe is now the Artist and one of the Assistant Palæontologists on the Geological Survey of Canada.) He obtained four specimens from this spot.

Mr. C. D. Walcott, describing "the Fauna of the Lower Cambrian, or *Olenellus* Zone," writes (p. 538):—"Geologists are indebted to the Geological Survey of Canada for the discovery of the *Olenellus*-zone in the Rocky Mountains of British Columbia. Dr. Geo. M. Dawson first obtained a species of *Olenellus*, like *O. gilberti*, at Kicking Horse Lake in British Columbia, and in 1887 Mr. R. G. McConnell described a section at Castle Mountain and Mount Stephen, which shows that the *Olenellus* fauna occurs at the base

[1] Read before the British Association for the Advancement of Science (Section C, Geology), Belfast, September 11th, 1902.

[2] After they have been examined by me Mr. Whymper will present them to the British Museum (Natural History).

of the Castle Mountain limestone, and that the Middle Cambrian fauna occurs 2,000 feet above." [1]

Subsequently Mr. Otto Klotz, whilst engaged on geodetic measurements in connection with the astronomical work of the Canadian Dominion, accidentally discovered the Trilobite bed on Mount Stephen, and presented the specimens he collected to the University of Michigan, his Alma Mater. The specimens afterwards were placed in the hands of Dr. C. Rominger, who described them in the Proceedings of the Academy of Natural Sciences, Philadelphia, 1887, pp. 12–19, pl. i. The descriptions are explicit, but the figures are not satisfactory, and I hope shortly to figure these Trilobites more fully. Meantime I am able to submit clear outline drawings of most of the species.

Dr. H. M. Ami, M.A., F.G.S., Assistant Palæontologist to the Geological Survey of Canada, Ottawa, who has visited Mount Stephen and geologized upon its slopes, kindly informs me that the beds containing the Trilobites represent about 300 feet in thickness. They form the summit of Mount Field, and rest at about 6,580 feet up on Mount Stephen; the summit of this latter mountain is composed of Palæozoic limestones, about 2,000 feet in thickness *above the black Trilobite shales*, the fauna of which has not yet been examined. Beneath the latter there are about 1,000 feet of calcareous and siliceous shales, while basal sandstones make up the residue.

	Section of Mount Stephen.	
1. At summit: Palæozoic limestones, fauna not yet examined	2,000 feet	Probably Upper Cambrian.
2. Black Trilobite shales	300 to 400 feet	Middle Cambrian fossils abundant (Walcott).
3. Limestones and shales, calcareous and siliceous shales	1,000 feet	Lower? Cambrian series (no fossils).
4. Sandstones, basal sandstones ...	1,530 feet	

One feature of the scenery is that the mountains (as a whole) are nearly all carved vertically.

Mr. S. H. Reynolds, M.A., F.G.S., has brought back a series of the fossils from Mount Stephen (Field); these are now in the Woodwardian Museum, Cambridge, and a small, perhaps larval form has been described and figured by Mr. F. R. Cowper Reed, M.A., F.G.S. (in the GEOL. MAG., 1899, Dec. IV, Vol. VI, pp. 358–361), and named *Oryctocephalus Reynoldsi*.

Dr. G. F. Matthew, Mr. C. D. Walcott, and Dr. Rominger have all described fossils from this locality, and the Survey of Canada at Ottawa has a fine collection made by their own officers and also by Mr. Byron Walker, F.G.S., of Toronto. The following fossils have been met with at Mount Stephen, viz.:—

[1] "Report on the Geological Structure of a portion of the Rocky Mountains": Geol. and Nat. Hist. Surv. Canada, new series, vol. ii (1886–7), pp. 28–30D, with section.

TRILOBITA.

Neolenus serratus (*Oggygia serrata*).
Olenoides Nevadensis.
Olenoides, sp.
Ptycoparia Cordillerœ.
Ptycoparia, sp.
Bathyurus Dawsoni.
Bathyuriscus Howelli (*Embolimus rotundata*).
Ogygopsis Klotzi.
Ogygopsis, sp.
Zacanthoides spinosus.
Oryctocephalus Reynoldsi (Cowper Reed).
Agnostus interstrictus.
Agnostus, sp.

PHYLLOCARIDA.

Anomalocaris Canadensis (Whiteaves).

BRACHIOPODA.

Obolella, sp.
Acrotreta gemma.
Kutorgina pannula.
Lingulella ella.
Scenella, sp.
Hyolithes, sp.
Theca, sp.

Dr. Ami, in reply to my queries, says:—"I do not know of any greater elevation than that of Mount Stephen from which Trilobites have been obtained, *unless* the Pioche Nevada or the localities in Utah (where the same fauna also occurs) attain to a greater elevation. It would be interesting to compare the heights of Canadian with United States localities."

Certainly the Mount Stephen Trilobite beds are the *highest* point in the Rocky Mountains where Trilobites have been found.

It is a generally accepted axiom in geology that the oldest mountains in the world are now the least in point of altitude, having been subjected for such vast periods of geological time to subaerial denudation that we now only contemplate their degraded remains; the strata composing them being also, as a rule, highly metamorphosed and crumpled.

Here, however, we are presented with mountains composed of Cambrian strata—the oldest stratified rocks we know containing living organisms—having an elevation of some 6,000 feet above the pass, or 10,000 feet above sea-level, *rich in well-preserved Trilobites*, but little distorted, the strata lying in horizontal sequence, and in almost the same undisturbed condition as on the day, millions of years ago, when these deposits were laid down in the depths of the primordial ocean.

Mr. C. D. Walcott places the Trilobite shales of Mount Stephen in the *Middle* Cambrian series; but Dr. G. F. Matthew considers them to be *Upper* Cambrian in age. A careful examination of the 2,500 feet of basal shales, limestones, and sandstones upon which the Trilobite-bearing beds rest, is essential, as, if Dr. Matthew's contention is correct, they should represent the Middle and Lower Cambrian. Similarly, the 2,000 feet of overlying limestones, forming the summit of Mount Stephen, ought in that case to yield Silurian fossils to the enterprising climber who should scale their precipitous cliffs.

At least a dozen genera of fossils have rewarded Mr. Whymper's researches, and in a newly explored valley named 'Ball's Valley'

(after the Alpine traveller, John Ball, F.R.S.), twenty-three miles distant from Field, Mr. Whymper discovered the same Trilobite- and Molluscan-bearing beds.

In addition to the Trilobites, etc., Mr. Whymper obtained good examples of *Anomalocaris Canadensis*, a remarkable phyllocarid Crustacean, described by Dr. J. F. Whiteaves, F.G.S., the Palæontologist to the Geological Survey of Canada.

Mount Field, which faces Mount Stephen, remains still unexplored, but is a part of the same *massif*, and will no doubt yield the same Cambrian fossils. It is only separated from its brother peak by the present pass, which glacial torrents working for long centuries have gradually widened into the existing river valley.

(*To be continued in our next Number.*)

VIII.—The Exploration of Kesh Caves, County Sligo, Ireland.

By Dr. R. F. Scharff, B.Sc., F.Z.S., and others.[1]

KESH, or as it is locally spelled 'Keash,' is fifteen miles south of the town of Sligo, and consists of a few scattered buildings, with farms about them. The spot is at the foot of Keishcorran Mountain, an isolated mass of Carboniferous Limestone which rises to 1,183 feet; and the country which extends south and west from this mountain for miles from Kesh presents an array of gravel eskers and elongated mounds of glacial material, with here and there a small lake or marsh in the hollows between them. Sprinklings of erratic boulders and stones occur up to the very summit of the mountain. These consist principally of red sandstone, with a few of yellow sandstone and of dyke rocks. It is believed that these rocks could be found in place on the next hill range to the south and south-east of Kesh, around Lough Key, but this point has not been definitely established. Though no continuous deposit of drift was seen on the mountain, these erratic blocks are sufficient to show that it has been overwhelmed by ice.

On approaching Keishcorran from Kesh one sees a grass-grown talus which extends up from the plain at a steep angle for several hundred feet. Surmounting this is a range of cliffs running along the mountain face like the gigantic walls of an ancient city. These are pierced along the top of the talus by a range of some thirteen caves. Towards the northern end of this series is a cavern whose large orifices, about fifteen feet high, can be seen for miles. The other caves are of various sizes, but the type which prevails is that of a vertical fissure enlarged downwards into an 'A' shape. The cliff which they penetrate faces S.W., or S.W. by W., and their direction is approximately parallel. These caves are intersected at various distances from their mouths by cross-fissures, which in

[1] Report of the Committee, consisting of Dr. R. F. Scharff (Chairman), Mr. R. Ll. Praeger (Secretary), Mr. G. Coffey, Professor G. A. J. Cole, Professor D. J. Cunningham, Mr. G. W. Lamplugh, Mr. A. McHenry, and Mr. R. J. Ussher, appointed to explore Irish Caves. Drawn up by the Chairman. Read before Section C (Geology), British Association, Belfast, September, 1902.

several cases form connecting galleries from cave to cave. This feature is more or less common to them all. The whole system of excavations, in fact, clearly depends upon the jointed structure of the limestone. The great cliff is due to the flaking away of the mass along one series of vertical joints, and solution works along the same series within, and produces passages and fissures parallel to the face. The caves connected by these fissures have also been worked out by solution, acting along the second vertical series of joints which run in perpendicularly to the great cliff face. The general slope of the cave floors is from within outwards, and the contained deposits are mainly the detritus and residue of the limestone rock, with fallen blocks from the walls and roof, set in a soft calcareous tufa.

Coffey Cave.—Our excavations were commenced in May, 1901, at the mouth of one of the larger caves, which is about central in the series, and which we distinguish as the Coffey Cave. It has a lofty A-shaped mouth, and a large deposit of clay occupies its lower portion. The section made in this across the cave's mouth disclosed the following deposits in descending order:—

1. *Surface soil* of a blackish brown, containing charcoal, a tine of Red Deer antler, the broken bones of domestic animals, and a few implements indicating temporary occupation by man rather than fixed settlement. The bones and implements are such as are commonly found in raths and crannogs, and the depth of this layer is from six to twelve inches.

2. *Breccia*, consisting of limestone blocks and fragments fallen from the roof, in a deposit of calcareous tufa. This bed contained numerous land-shells (*Helix, Hyalinia, Clausilia*) and bones of small mammals. Among these the Arctic Lemming was numerously represented as well as in the next stratum. This is the first instance in which this animal has been identified as a former inhabitant of Ireland. A mandible has been referred to the Irish Stoat, though smaller than that of a Weasel; and some canine remains have not yet been definitely identified. The depth of the breccia is from a foot in the centre increasing to three feet at the sides of the cave.

3. *Clay* of a brown ochreous colour containing large blocks of limestone and numerous bones of small mammals (including Lemming), as well as a few of larger ones. At a depth of six feet from the surface a large glaciated block of limestone was found.

Plunkett Cave.—Owing to the difficulty of removing the numerous limestone blocks we searched for more promising ground and decided to work at a smaller cave, one of the most southern of the series, which opened at a somewhat higher level. We called this the Plunkett Cave. A lofty entrance narrows down to a low mouth, from five to six feet wide, and inside this the cave becomes much more lofty and widens at a distance of from twelve to sixteen feet from the mouth. It then forms a gallery six to ten feet wide which pursues a generally straight course, terminating at forty-nine feet from the mouth. Before this termination is reached, however,

a gallery branches off to the right, and this, after running some twenty feet, expands into a lofty hall, the Sloping Chamber, that has another branch to the left, parallel with the Plunkett Cave. We called this latter branch the Water Gallery.

At the commencement of the operations no part of these galleries was completely choked, but all contained a considerable depth of deposits, chiefly of earths and clays, with blocks and fragments of limestone.

The upper or surface stratum, which varied from six inches to two feet in depth, contained a large amount of calcareous tufa, and as we advanced into the inner galleries this tufa grew more and more free from earthy admixture, being in places as white as mortar. While a variable amount of calcium carbonate occurs in this deposit, its whiteness is in part due to the usual residue of siliceous particles that results from the removal of limestone in solution. Characteristic bipyramidal crystals of quartz are thus found in some parts; and in the Water Gallery a delicately spicular deposit occurs. A multitude of minute rods, sometimes set with knobs, are seen when the tufa is dissolved away in acetic acid. Dr. G. J. Hinde, F.R.S., who has kindly examined these for us, points out that they are crystalline and soluble in nitric acid. Their true character is still under consideration. In all parts of the cave explored by us this white stratum contained charcoal, sometimes in lumps and occasionally in horizontal layers, which formed distinct seams in our sections. In the most remote part excavated by us, the Water Gallery, there was a black layer of charcoal an inch deep, which extended from wall to wall, with a bed of white tufa above and beneath it, and at the bottom of the lower tufa there was more charcoal. Some pieces of peat were also found embedded elsewhere, which were probably brought into the cave for fuel.

In the lower part of the upper stratum a large stone celt was found five feet inside the cave's mouth, the only evidence of Neolithic occupation, and not far from it was a portion of a small iron saw of peculiar make, resembling those found in Dunshaughlin crannog, and in the same vicinity a bronze pin with a ring attached to it. The upper stratum contained a second bronze pin at thirty-eight feet from the mouth of the cave, and further in again was a small iron rod. Shells of marine Mussels repeatedly occurred in this upper stratum and also an oyster-shell, though the sea is now fifteen miles distant, and it is not likely to have been much nearer in Neolithic times.

The human remains were few, and occurred chiefly near the Sloping Chamber; but the bones and teeth of domestic animals were exceedingly numerous, and were found wherever the stratum extended. These were generally fragmentary and represented the species usually found in Irish kitchen middens, viz., horse, red deer, ox, sheep, goat, pig, and dog.

Among the wild species represented in this upper stratum fox and rabbit were numerous, hare and red deer less so; but an interesting find was a metatarsus of reindeer, which occurred in

the gallery to the right, deep down in this stratum; while charcoal was found lower down in the same deposit and in the same bench, each bench measuring two feet wide.

In several parts of the cave the upper stratum contained bones of brown bear. These were found near the lower horizon of the deposit, so that in some cases they may have been lying on the surface of the clay which formed the second stratum where the deposition of the upper one commenced. In one case a bone of a bear was partly embedded in the upper stratum and partly in the clay.

Bones of field mice were numerous, as well as those of frog.

The second stratum of clay, which also extended throughout the galleries of the Plunkett Cave, was brown, inclining to ochreous, more or less sandy, and contained numerous fragments of limestone and chert. Worn rounded pebbles were scarce in the clay, and occurred chiefly in or near the Water Gallery.

The quartz sand in this yellowish clay seems to be truly detrital and of external origin; it sometimes largely predominates over the clayey particles. The clay itself, however, probably arises from the decay of certain layers of the limestone, since it contains, and at times abundantly, the typical bipyramidal crystals of quartz. Its non-calcareous nature shows that it was deposited when solution was fairly active, while the upper tufaceous deposits indicate conditions favourable to stalagmitic growth.

The presence of occasional worn pebbles of red sandstone in the interior of the caves might be explained on the supposition that the pebbles had been washed down pot-holes and crevices from the hill above. The gravelly deposit at the mouth of the Plunkett Cave could not, however, be thus explained. It is too thick and too limited in area, and some of its contained boulders are too large to have been thus introduced, and there seems no escape from the conclusion that the gravel has been washed to the mouth of the cave from without.

Some of the larger limestone boulders, especially those towards the top of the gravel, were undoubtedly glaciated (not only scratched, but exhibiting also the characteristic shape of glaciated blocks), and did not seem to have been worn or washed much since this glaciation.

There is not enough drift on the mountain above to explain the presence of the gravel as a down-wash, even if the contour of the hill were such as to render a down-wash of this kind possible, which is not the case. The plain of drift, with its characteristic original moundy topography, lies considerably below the mouths of the caves, with a steep talus slope now separating them, and it is highly improbable that there has ever been a plateau of drift material so high as the mouths of the caves at any time since the disappearance of the ice. There seems, therefore, to be no other explanation possible for the gravel deposit than that it has been washed into the mouth of the cave at a time when the ice was at least as high as the escarpment into which the caves are cut, and that the mouth of the Plunkett Cave was already an open passage at that period.

Hence it becomes a point of much importance to determine whether the caves contain any deposits of older date than the Glacial Period, and this point deserves especial prominence in any future exploration. The yellow clay with chert, the lowest deposit discovered, is not a true 'Boulder-clay.' It seems to be such material as might be derived from the solution of the limestone mixed with sand and mud from the waters entering the cave from without. We were not satisfied that this clay was older than the gravel deposit. No fossils having as yet been found in the yellow clay, the question as to its relation to the Glacial Period is at present of geological interest only, and no palæontological point is involved.

If a fossiliferous deposit were discovered below the yellow clay it would be of much scientific interest. That pre-glacially filled fissures may occur in the Carboniferous Limestones in this country is shown by the presence of an earth-filled fissure overlain by Boulder-clay in a limestone quarry at Howth, which one of us examined recently, but without noticing any fossils in it.

A block and cone of crystalline stalagmite were found in the clay in the Water Gallery, but these were the only examples noticed of this ancient form of stalagmite which had evidently been broken up in this cave.

The lower portion of the clay seemed to be devoid of bones as well as of any relics of man, but in the upper portion of this deposit we found animal remains, including a human tooth; and a little charcoal was met with in four different spots. This strongly contrasted with the abundance of the latter material, which was everywhere present in the upper stratum; and even these few traces of it must be mentioned with caution, as burrowing animals may have penetrated into the clay, and thus might have transmitted into it some bits of charcoal from the upper stratum. Remains of domestic animals, so abundant in the latter, were virtually absent from the clay, a bone or two of ox and of goat being all the relics in it assignable to those mammals. The pig was, however, represented in four places.

The characteristic animal throughout this stratum was the brown bear, whose bones and separated teeth numbered sixty at least, and occurred in all parts of the cave, becoming more frequent in the inner galleries. Fox was found in fourteen places, hare in seven, red deer in four, rabbit in three, wolf in at least one instance, and lemming once (at the entrance), while frog and field-mouse occurred repeatedly.

We sank deep sections in several parts of the cave, with the result that it was found to narrow downwards and was filled in that direction with barren clay, which became yellow and tenacious as the rock was approached in our excavations. Near the cave's mouth large quantities of yellow clay were found, and it may be proper to treat it as a separate deposit distinct from the brown sandy clay. No drift stones have been noticed in the yellow clay.

It will be seen from this report that during the deposition of the upper strata the Plunkett Cave was inhabited for a long time by

men who used domestic animals and marine molluscs, and had implements of iron, bronze, and polished stone, and who, in the earlier part of this period, were contemporaneous with the reindeer and probably with the bear.

In the subjacent clay there are evidences, left during a previous epoch, that bears then inhabited the cave undisturbed by human intrusion.

Tabular Statement of the Mammalian Remains (Preliminary).

	Surface Stratum.	Breccia.	Clay.
Pig (*Sus scrofa*)	×	—	×
Horse (*Equus caballus*)	×	—	—
Ass (*E. asinus*)	×	—	—
Red Deer (*Cervus elaphus*)	×	—	×
Reindeer (*Rangifer tarandus*)	×	—	—
Sheep (*Ovis aries*)	×	—	—
Goat (*Capra hireus*)	×	—	?
Ox (*Bos taurus*)	×	—	?
Field-mouse (*Mus sylvaticus*)	×	×	×
Rat (*Mus decumanus*)	×	—	—
Arctic Lemming (*Dicrostonyx torquatus*) ...	?	×	×
Rabbit (*Lepus cuniculus*)	×	×	?
Hare (*Lepus timidus* = *variabilis*) ...	×	×	×
Bear (*Ursus arctos*)	×	—	×
Dog (*Canis familiaris*)	×	?	?
Wolf (*Canis lupus*)	×	—	?
Fox (*Vulpes alopex*)	×	—	×
Badger (*Meles taxus*)	×	—	—
Irish Stoat (*Putorius hibernicus*)	—	×	—
Man (*Homo sapiens*)	×	—	?

IX.—On the Brockrams of the Vale of Eden, and the Evidence they afford of an Inter-Permian Movement of the Pennine Faults.[1]

By Percy F. Kendall, F.G.S.

THE author has been engaged during occasional visits to the Vale of Eden in the study of the well-known Brockram conglomerates which form so conspicuous an element in the Poikilitic series of the district. Tentative results obtained five or six years ago have been fully confirmed by later observations, and though the investigation is not quite complete, the author regards the present occasion as an opportune one for presenting a preliminary statement of views which have already obtained some currency by annual demonstrations in the field to scientific societies of the North of England.

The stratigraphical relations of the Brockrams can be well studied in the almost continuous sections which are exposed between Hoff Beck, two miles west of Appleby, and Brackenber Common, three

[1] Abstract of a paper read before the British Association, Belfast, September, 1902, in Section C (Geology).

miles east of the town. The beds dip to north-east at about 20 degrees, and the succession here exposed is as follows:—

St. Bees Sandstone (Trias).

PERMIAN.
6. Shales and Sandstones.
5. Hilton Plant Beds.
4. Magnesian Limestones.
3. Upper Brockram interbedded with and overlain by Penrith Sandstone.
2. Penrith Sandstone.
1. Lower Brockram.

Carboniferous rocks.

The Lower Brockram forms a bold escarpment near Hoff Beck, and the nature of its constituents can conveniently be studied in great clean faces of quarries as well as in natural exposures. In the course of a careful examination of the pebbles it has been found that all the pebbles, except some twenty or thirty at most, consist of Carboniferous limestone or chert, the former well rounded and frequently very fossiliferous—*Saccamina Carteri* was found in one. The stones ranged in size up to nearly a foot in diameter.

The few exceptions mentioned above were hæmatite, sandstone, and ten or twelve small pebbles of vein quartz such as might be found in the Millstone Grit, the Basement Carboniferous Conglomerate, or, more remotely, as veins in the Skiddaw Slates. Recurrences of the same bed, presenting the same characters as regards the nature and source of the pebbles, are seen on the west bank of the Eden below Appleby, on Gallows Hill, and at Hungriggs quarry, east of Appleby. At the last two localities the pebbles have been very extensively dolomitized subsequently to deposition, for the pebbles have in many cases been reduced to a mere shell, usually lined with crystals of calcite.

The same aspect of the Lower Brockram is presented in the exposures at Stenkreth (Kirkby Stephen) and to the northward of Hungriggs in several quarries. It can be seen from these facts that for a distance of ten or twelve miles along the strike, and for over two miles on the dip, the character of the pebbles in the Lower Brockram undergoes no change.

The Penrith Sandstone about Appleby attains to a thickness of probably a thousand feet, but no exact estimate is possible owing to the occurrence of a large number of faults, of unknown throw.

Near its upper boundary, numerous intercalations of the Upper Brockram Conglomerate occur, especially in the section in Hilton Beck.

The Upper Brockram in this section consists of a rather friable conglomerate, in beds of a foot or two in thickness, parted by beds of sandstone from a few inches up to 30 or 40 feet thick. The constituent pebbles are partly of Carboniferous Limestone, very soft and much dolomitized, but other elements frequently preponderate; these are well-rounded pebbles of vein quartz, angular pebbles and blocks of quartzite, fragments of conglomerate containing

vein quartz in a quartzite matrix, and finally pebbles of rhyolite. At other exposures to the northward at Flakebridge the same characters recur.

The source of the different pebbles may now be considered. The limestones are of course from the lower part of the Carboniferous Series; they present peculiar features. The pebbles of vein quartz are clearly derived from the numerous quartz veins in the Skiddaw Slate of the Cross Fell inlier, but their thoroughly rounded condition shows that they must have come at an intermediate stage through some pre-Permian conglomerate. This conclusion is confirmed by the occurrence of fragments of conglomerate containing such pebbles, which is recognizable as the very characteristic Basement Carboniferous Conglomerate of the Cross Fell Range.

The angular blocks of quartzite can be matched precisely by the rocks which succeed the Basement Conglomerate of Roman Fell. The author at one time regarded the rhyolites as indisputable evidence of the exposure of the Borrowdale rocks of the Cross Fell inlier and denudation during Permian times, but while this still seems to be the most probable explanation of their presence in the Upper Brockram it is possible that they could have been derived from the Carboniferous Basement Conglomerate, in which at Swindale Beck a few such pebbles occur.

Setting aside the rhyolite pebbles, there is still a body of evidence which seems to warrant deductions of very great interest. The facts to be explained are the occurrence in the Lower Brockram of a practically pure gathering of Carboniferous Limestone, while the Upper Brockram contains a very high percentage of rocks from the very base of the Carboniferous Series. They might be explained on the supposition of derivation from opposite sides of the Vale of Eden, the Lower Brockram being supposed to come from the Carboniferous Limestone outcrop towards Orton, while the Upper Brockram was derived from the Pennine Range. This view has little to commend it. If the Carboniferous Basement Conglomerate were exposed to denudation during the deposition of the Upper Brockram, then the Carboniferous Limestone must have formed a bold escarpment at the same time; and that being granted, it is highly improbable that it failed to yield the materials of the Lower Brockram, which at Hungriggs is less than three miles from the outer Pennine fault which exposed a series of Carboniferous rocks in Permian times. Upon the alternative, and as it seems preferable, hypothesis, that the materials of the two Brockrams were all derived from the Pennine Chain, an inter-Permian movement of the faults which throw up the Cross Fell range and the well-known inlier seems necessary.

Professor Lapworth has pointed out that when an anticlinal fold is exposed to denudation the derivative beds will consist of the same material as those of the anticline, but in reverse order, the uppermost beds of the anticline will yield the pebbles of the lowest of the derivative beds, while the core of the anticline will be represented only in the highest of the derivative beds.

This principle may be illustrated by the Tertiary beds of the south-east of England; the Lower Eocene conglomerates contain

only flint pebbles from the Chalk, while the high-level gravels which rest on the Bagshot series contain besides flint many pebbles derived from the Lower Greensand.

Where, however, the exposure is by a fault scarp the whole of the beds exposed in the scarp will contribute to the first-formed derivative conglomerates. The absence of detritus of the Basement Carboniferous from the Lower Brockram shows that the basement beds were not exposed in early Permian times, but a movement of the fault exceeding the thickness of the Penrith Sandstone brought the lowest members of the Carboniferous series above the surface at the time of the deposition of the Upper Brockram.

X.—On the Sequence of the Inferior Oolite Deposits at Bredon Hill, Worcestershire.

By L. Richardson, F.G.S.

THE correct sequence of the Inferior Oolite deposits at this locality has always been a matter of uncertainty. This is due partly to the disturbed state of the oolite, partly to the scarcity of fossils. On Bredon Hill only the four lowest subdivisions of the Inferior Oolite series are preserved. In the Cotteswold Hills around Cheltenham they are, in descending order, the Lower Freestone, Pea-grit, Lower Limestone, and sandy beds characterized by a very distinctive ammonite, *Tmetoceras scissum* — the last being the sandy ferruginous limestones of Witchell. Professor Hull did not recognize the Pea-grit at Bredon, but stated that its most northern extension was at Notting Hill.[1] In 1863, however, Dr. Holl rectified this error, and remarked that its non-existence here was only true as regards its pisolitic structure.[2] Above Elmley Lodge that author noticed masses of limestone crowded with fragments of the spines and plates of Echinoderms, as well as numerous specimens of Bryozoa, and *Terebratula plicata*. Below the brow of the eastern extremity of the hill, above Ashton-under-Hill, Dr. Holl obtained *Rhynchonella cynocephala* in blocks of hard limestone, but was unable to find the bed *in sitû* or to offer any suggestion as to its probable stratigraphical position.

One mile north-west of Overbury Church is a large quarry, and although the strata here—as in the rest of the hill—are very much disturbed, it is possible to construct the sequence and also to obtain approximately the thickness of the several subdivisions. The sequence may be obtained by a study of the section afforded on the east side of the quarry.

The continuity of the sequence of the deposits is interrupted by a fault. On the north side about 12 feet of Lower Freestone is exposed, resting upon the equivalent of the Pea-grit. The top beds of this Pea-grit equivalent consist of hard yellowish limestones full of fragments of the spines and plates of Echinoderms. Capping the projecting mass of rock—separated from the east face of the quarry

[1] Mem. Geol. Surv.: "Geology of the Country around Cheltenham" (1857), p. 33. Notting Hill is locally known as Nottingham Hill.

[2] Quart. Journ. Geol. Soc., vol. xix (1863), p. 315.

by a small fault—similar yellowish limestone is seen, and passes downwards into a shelly development. *Terebratula simplex* (but only the pedicle valves) is abundant. The shelly rock is best exposed in the west side of the southern or disused portion of the quarry, and contains *Terebratula simplex, Ter. plicata, Rhynchonella subangulata, Rhyn. oolitica, Zeilleria circularis, Pygaster semisulcatus* ?, *Diastopora, Spiropora straminea*, etc., and ossicles of *Pentacrinus*. About 2 feet of hard yellowish-white oolitic limestone is visible below the Pea-grit, which latter attains a thickness of about 14 feet. On the south side of the fault the shelly strata of the Pea-grit are inclined at a high angle and rest upon a massive deposit of yellowish-white oolitic limestone, thickly bedded in its upper portion but becoming flaggy below. This Lower Limestone is about 34½ feet thick. The whitish flaggy development is seen capping the promontory on the opposite side of the quarry, and passes downwards into brown arenaceous strata, very ferruginous in places, and becoming more compact towards the base. This arenaceous rock—also containing fragments of sea-urchins abundantly—is exposed for a thickness of 13 feet. To the floor of the quarry is about 7 feet, and to the water-retaining stratum from this point, as proved in an old well, is about 8 feet. Thus, from the top of the arenaceous strata to the water-retaining bed is about 28 feet.

From evidence obtained in an old pit about 200 yards north-west of Kemerton Castle the thickness of this deposit, which contains a few *Rhynchonella cynocephala, Ter. euides*, and Belemnites, was estimated at 33 feet. In many quarries on the hill it may be noticed that the thickness of the Lower Freestone is very considerable.

Summarized, our knowledge of the Inferior Oolite at this locality is as follows:—

(1) Lower Freestone. Whitish oolitic freestone.

(2) Pea-grit equivalent. Compact yellowish limestone containing fragments of Echinoderms and a few of the characteristic Brachiopoda. 14 feet.

(3) Lower Limestone. Massive bedded yellowish-white oolitic limestone. 34½ feet.

(4) *Scissi* beds. Brown ferruginous, sandy strata containing *Ter. euides, Rhyn. cynocephala*, and a few Belemnites. 33 feet.

NOTICES OF MEMOIRS, ETC.

I.—Earthquake Investigations.[1] By Professor John Milne, F.R.S., F.G.S. (Reporter).

At the present time this Committee enjoys the co-operation of 38 similarly equipped observing stations, which are distributed in a fairly even manner over the different continents. All large earthquakes are recorded at each of these stations. At Professor Milne's station in the Isle of Wight the number of records obtained during the year is about 150. A map accompanying the Report shows

[1] Report of Committee read before Section A (Mathematical and Physical Science), British Association, Belfast Meeting, September, 1902.

the origins from which these world-shaking disturbances have originated. Nearly all of these, fortunately for humanity, are suboceanic and remote from thickly populated shores. From the sea-waves they sometimes create, the increase in oceanic depths found to have taken place after their occurrence, and the subsidences or upheavals of neighbouring shore-lines, the inference is that their cause is a caving in of some ill-supported portion of the earth's crust; a furrow on the face of the world has been deepened, whilst a bounding ridge may have been elevated. When these stupendous changes have taken place near to a volcano which has long been dormant, the violent shakings of its foundations have resulted in the imprisoned vapours suddenly bursting into activity. An activity of this description was apparently the immediate cause of the recent disasters in the West Indies; in fact, all the recorded eruptions in these islands have been preceded by sudden adjustments in neighbouring rocky folds.

Another section of the Report treats of the nature of the waves which so frequently pass through our earth and sweep its surface. Although this, like other sections, is of interest from a purely scientific standpoint, we observe that many of the investigations, as for example those bearing upon the choice of a site for an observatory, localizing districts where it would be unwise to lay a cable, have practical bearings of considerable importance.

With a desire to extend seismological investigations on the lines inaugurated by the British Association, we learn that the German Government had approached other nationalities inviting international co-operation. The Report before us indicates that co-operation of this nature is to a great extent *un fait accompli*.

II.—Note on the Occurrence of Bagshot Beds at Combe Pyne, near Lyme Regis.[1] By Horace B. Woodward, F.R.S.

In the Summary of Progress of the Geological Survey for 1900, p. 122, Mr. Clement Reid remarked, "It is probable that a chain of outliers of the Bagshot river-gravels will connect the Eocene of Dorset with that of Bovey Tracey in Devon."

The cuttings on the new railway between Axminster and Lyme Regis have since displayed, in the neighbourhood of Combe Pyne Hill, at an elevation of about 400 feet, beds of fine white sand, white pipeclay, and white, red, and mottled stony clays, with much rough flint and chert gravel. These beds have in places a marked inclination towards the east, due probably to original deposition, and in all respects they bear a close resemblance to the white and coloured clays and sands, and the coarse gravels, which border the Bovey basin at Wolborough and other places near Newton Abbot. They rest on a platform of Upper Greensand.

The beds at Wolborough I some years ago regarded as equivalent to the 'plateau drifts' of Haldon, but Mr. Reid has recently brought

[1] Abstract of a paper read at the British Association, Belfast, September, 1902, in Section C (Geology). Communicated by permission of the Director of the Geological Survey.

forward evidence to show that both are for the most part of Bagshot age, with the exception only of the deposits that have been rearranged in later times. There is, therefore, good reason for referring to the Bagshot series the beds at Combe Pyne, which are evidently *in sitû*, and which possess so many of the features characteristic of that formation.[1]

III.—The Geology of the Country in the Neighbourhood of Belfast.[2] By Professor Grenville A. J. Cole, F.G.S.

BELFAST stands between the lava-plateaux of Cainozoic age in Antrim and the undulating surface of Silurian rocks in county Down. The special interest of the district lies in the preservation of Mesozoic rocks, which elsewhere are scarcely represented in Ireland. Schists and gneisses in the north-east of county Antrim possibly represent Archæan masses refolded during the Caledonian earth-movements. The Caledonian folds gave us the crumpled country of Down, and admitted the granite of Newry and Castlewellan along an axis running north-east and south-west. Both Ordovician and 'Upper Silurian' (or Gotlandian) strata are represented in this area. The conglomerate of Cushendun is probably of Old Red Sandstone age; but the Carboniferous Limestone, which is so marked a feature of Ireland as a whole, plays only a small part in the north-eastern counties. The Carboniferous strata of Ballycastle, west of Fair Head, are mainly sandstones with intercalated coal-seams, on the same horizon as the Calciferous Sandstone of the South of Scotland.

A patch of marine Permian strata occurs east of Belfast, at Holywood; and the British type of Trias, red rocks with salt and gypsum, is well represented under the basalt capping that has preserved it. The Rhætic sea spread into this area, and terminated far west against the Londonderry highlands; the Lias also began to form, and is now finely exposed at Waterloo, close to Larne. It is questionable if higher Jurassic beds than those now left to us were ever laid down in this region; elevation and denudation certainly set in early, and the country remained dry land until the middle of Cretaceous times. Then, in the westernmost extension of the great Chalk sea, the sands, conglomerates, and white limestone of Antrim were deposited, representing the Upper Cretaceous of England in a thickness of about 100 feet. The cliffs of hardened chalk, between red basement-beds of Trias and the black basalt scarp above, form, in Glenariff and Murlough Bay, one of the most beautiful contrasts in our Islands. It is clear that in early Eocene times both the counties of Antrim and Down were covered with a rolling series of Chalk uplands, resembling on a less massive scale our present Salisbury Plain. This quiet and newly upheaved country was destined to be devastated by volcanic action, more continuous and extensive than had been seen in the British Isles since Old Red Sandstone times.

[1] Particulars of the sections are given in the Summary of Progress of the Geological Survey for 1901, pp. 53–59.

[2] Read before the British Association, Belfast, Sept. 1902, in Section C (Geology).

The ground was first broken by rifts running from south-east to north-west, and these were quickly filled by basic lavas. Flow after flow emerged across the country, filling up the hollows carved by denudation, and forming in time continuous plateaux. Although a few explosive vents were established here and there, fluid basalt was the great feature of these eruptions. A time of quiet followed, when the lake-deposits and iron-ores of Glenarm, Ballypalady, etc., were accumulated; and sporadic outbreaks of rhyolite appeared, the most prominent being that of Tardree Mountain. Then the basic eruptions were renewed, and the columnar basalts of the Causeway coast belong to this second epoch of activity.

Mr. Starkie Gardner has referred these volcanic masses of Northern Ireland to early Eocene times, from a study of the plant-remains in the associated lake-deposits. Hence we find the marine Cretaceous beds followed by a terrestrial and igneous Eocene; and possibly some of the latest vents were active in Oligocene times. Thenceforward we know nothing of Irish geological history until the Glacial Epoch, which has left such piles of Boulder-clay and gravel across the country. The latest feature of interest is the blue marine clay of Belfast and Magheramorne, full of exquisitely preserved post-Pliocene fossils. This lies unconformably on the glacial drift, and represents a comparatively recent submergence and re-elevation. The raised beach of Larne, with flint-chips in it prepared by man, indicates the modern date of the movements of elevation.

When we go south from the immediate neighbourhood of Belfast, the Mourne Mountains rise conspicuously, their summits being far more bold than those of the adjacent Caledonian granite ridge. They are also formed of granite, which cuts across basic masses; the latter are seen at Carlingford to be at any rate post-Carboniferous. In turn, a few basic dykes of still later date traverse the granite. By its relation to these two basaltic series, and its petrographic identity with the Cainozoic granites of Mull and Skye, we need not hesitate to regard the Mourne granite as of Eocene age. It forms, then, as Mr. McHenry has pointed out, an interesting deep-seated mass for comparison with the rhyolitic lavas of the inter-basaltic epoch in county Antrim.

From the above notes, which have no claim to originality, it will perhaps be seen how attractive the Belfast area is to geologists, by reason of its very contrast with the accepted types of Jurassic, Cretaceous, and Cainozoic deposits, as known to us in the London Basin. Those familiar, on the other hand, with the geology of the Scottish Isles, will find many interesting points of similarity.

IV.—The Post-Glacial Deposits of the Belfast District.

By R. Lloyd Praeger.[1]

THE silted-up head of Belfast Lough and other similar places in the district display a remarkably fine series of deposits extending from the close of the Glacial epoch to the present day, with a rich

[1] Abstract of a paper read before the British Association, Belfast, September, 1902, in Section C (Geology).

fauna, from which much of the history of the intervening period may be gleaned. A typical section at Belfast shows the following sequence :—

	ft.	in.
Surface clays	6	6
Yellow sand	2	0
Blue clay { Upper	6	0
Blue clay { Lower	6	0
Grey sand	2	0
Peat	1	6
Grey sand	2	0
Red sand	4	0
Boulder-clay (base not reached)	15	0
	45	0

The peat bed, which at Belfast is twenty feet below low-water level, reappears between tides at various other places in the district. It represents an old land-surface, and its fossils include the 'Irish Elk.' The blue clay is the most important bed of the series. Two divisions can be clearly distinguished in it, the lower clay being littoral, and characterised by such shells as *Scrobicularia piperata*, the upper yielding an abundant fauna pertaining to five to ten fathoms of water. *Thracia convexa* is a characteristic fossil. In both clays some of the bivalves occur in beds, each shell in its natural position, and many of the species attain remarkably large proportions. In places the *Scrobicularia* clay is overlaid by raised beaches. Thus, at Larne, twenty feet of stratified gravels, containing marine shells and neolithic implements throughout, replace the *Thracia* clay, and serve to date it. The fauna of the *Thracia* clay has a distinctly southern aspect when compared with the present fauna.

As regards oscillations of level, the peat proves a level higher than the present in certain places by at least thirty feet. Subsidence, irregular both as regards rate and area affected, superseded to the extent of fifty to eighty feet; the final elevation, which brought about the existing state of things, amounted to thirty or forty feet.

As regards climate, the northern fauna of the Glacial period appears to have passed away by the time the peat was formed. Southern species immigrated till the molluscan fauna acquired a distinctly southern character in the upper blue clay; then the seas became again colder, and the present local molluscan fauna has a distinctly northern aspect.

V.—On the Marine Fauna of the Boulder-Clay.

By Joseph Wright, F.G.S.[1]

THE author has examined microscopically 112 samples of boulder-clay from various places in the British Isles and in Canada: 47 of these were from Ireland, 27 from England and Wales, 22 from Scotland, 1 from the Isle of Man, and 14 from Canada. In 71 of the British and in 9 of the Canadian samples foraminifera were found; the specimens of the clays had been taken from various

[1] Abstract of a paper read before the British Association, Belfast, September, 1902, in Section C (Geology).

altitudes, some few of them from localities over 1,000 feet above the sea. Almost all the forms found are referable to species which at present live at moderate depths off our coast, and most of them have the fresh appearance of these species. *Nonionina depressula* is often met with in great profusion, fully one half of the entire specimens found being referable to this species. One hundred and thirteen species have been found in the clays of Ireland, 72 in those of the Isle of Man, 65 in England and Wales, 40 in Scotland, and 15 in Canada.

In 31 of the gatherings no foraminifera were met with, whilst in some of the others they were very rare. The absence or the scarcity of specimens in some of the samples may be due, in part at least, to the circumstances that it was only the first floatings from the clays that were examined, and also that these minute organisms are liable at times to be overlooked when the material is being examined. To ascertain how far floatings could be relied on for giving conclusive results, 1 oz. troy of the boulder-clay from Woodburn, near Carrickfergus, was examined with the utmost care. The first floating was found to contain 1,400 specimens, the floating process being repeated 25 times before specimens ceased to come up; upwards of 600 additional specimens were thus obtained. What remained of the clay was then examined in detail with the microscope, and 67 more specimens were got from it.

In the boulder-clay at Knock Glen, near Belfast, 79 species were obtained, many of them being very rare forms, 6 being only known as recent British species from collections on the west coast of Ireland, 2 of these also occurring off the west coast of Scotland. The presence of these microzoa would lead us to infer that the clay at this place was probably deposited in deep water, when the land stood at a much lower level than at present, and when the marine conditions must have been somewhat similar to what now prevails off the west coast of Ireland.

VI.—The Fossil Flora of the Cumberland Coalfield.[1] By E. A. Newell Arber, M.A., F.G.S.

THE Cumberland Coalfield lies along the coastline to the west of the mountains of the Lake District. The towns of Whitehaven, Workington, and Maryport are three of the most important centres of the coal industry in Cumberland. In this district the Upper Carboniferous rocks consist of two series, of which the upper is the well-known 'Whitehaven Sandstone.' This is essentially an arenaceous deposit, and is often red or purple in colour. It is generally believed to lie unconformably on the 'Coal-measures' below, the latter consisting of argillaceous and carbonaceous material, and containing almost all the workable coals.

The horizons of both the 'Whitehaven Sandstone' and the 'Coal-measures' in the Carboniferous are disputed questions.

[1] Abstract of a paper read at the British Association, Belfast, September, 1902, in Section C (Geology).

Recently some attempt has been made to throw fresh light on the subject, from the evidence of the plant-remains which occur in both series, although not so abundantly as in some other coalfields. A full account of the floras, and the conclusions which have been attained, will, it is hoped, be published shortly elsewhere.

VII.—A Summary of the Principal Changes in South-East England during Pliocene and more Recent Times.[1] By Horace Woollaston Monckton, F.L.S., F.G.S.

(*a*) *Period of depression in South-East England.*

1. Deposition of the bed from which the Box Stones came.

2. The Lenham Beds. Sea 40 fathoms, extends to Guildford, shells not rolled, level 1,000 feet lower than now (Diestian).

(*b*) *Elevation in South-East England, but depression continues over estuary of Rhine.*

3. Gravel with large flints of Upper Hale, Aldershot, and the Pebble Gravel ('Westleton') of the Chilterns.

4. Coralline Crag, submarine banks in rather shallow water; climate that of South Europe.

5. Red Crag of Walton and Scaldisian of Belgium; sea-shore deposits, climate rather warmer than now.

The beds with *Corbula gibba* (Poederlian) complete Belgian series, and that country becomes dry land.

6. Red Crag of Bentley, Newbourn, Butley, sea-shore deposits. The Amstelian of Holland. Climate colder.

(*c*) *The depression of the estuary of the Rhine extends to South-East England.*

7. Norwich Crag deposited in sea-water of wide estuary. Chillesford Clay, shells not rolled or water-worn, level lower than now.

8. Weybourne Crag and Bure Valley Beds, depression extending and consequent introduction of *Tellina balthica.*

(*d*) *Period of great and extensive elevation.*

9. Cromer Forest Bed, level and climate as now.

10. *Leda myalis* Bed, marine with oyster-beds, shells in position of life. Slight local depression.

11. The Chobham Ridges Gravel and the Plateau Gravels around Reading over 300 feet O.D. come in here.

12. Arctic Fresh-water Bed, flood loam with *Succinea.*

The shells of Bridlington Shell Bed lived about this time.

13. The Cromer Till and Contorted Drift. First great ice-sheet. Lower Boulder-clay of many places, Bridlington Shell Bed, and Shell Bed of Moel Tryfaen, etc. Land higher than now.

(*e*) *Depression possibly only local in South-East England.*

14. The Middle Glacial Sand and Gravel, result from melting ice.

[1] Read before the British Association, Belfast, Sept. 1902, in Section C (Geology).

(*f*) *Period of renewed great elevation possibly continuous with period* (*d*) *in the far north.*

15. The Great Chalky Boulder-clay. Ice-sheet extending over large area.

N.B.—At some time during Periods (*d*), (*e*), (*f*), the land in North Europe was raised to some 8,000 feet higher than now, and this is probable date of completion of excavation of Scottish lochs and Norwegian fjords.

(*g*) *Period of depression.*

16. *Corbicula fluminalis* Beds of Grays and Crayford. Mammiliferous beds of Sewerby and Hessle. Slight depression.

Marine Gravel of Holderness 100 feet O.D., Brighton, Goodwood, etc., Raised Beaches. Further depression.

(*h*) *Period of elevation over large area. Last great ice-sheet.*

17. Plateau Gravel of Norfolk in part, and much of the Thames Terrace-gravel. Purple and Hessle Clay of Yorks.

Shell-banks of Rockall, etc., show elevation of Iceland, Scotland, Norway, to some 600 feet higher than now.

18. Mundesley 'River Bed' near close of this period.

Probably the Raised Beach of Clacton, etc., belongs to a final period of depression (time of Yoldia Clay of Christiania), and in Norway there was a subsequent elevation during which the terraces in the fjords were formed.

VIII.—A British and a Finland Meteorite.

IT is of extreme interest to record that a meteorite fell near Crumlin, county Antrim, on Saturday, September 13th, at 10.30 a.m. Although the British Association was holding its meetings ten miles away, no one thought it worth while to investigate what appeared to be a hoax, and it remained for Mr. L. Fletcher to go over about a week later and secure the stone for himself. We quote Mr. Fletcher's own account of this fall, which appeared in the *Globe* newspaper:—

"As for the stone itself, it weighs 9 lb. $5\frac{1}{2}$ oz.; it is $7\frac{1}{2}$ inches long, $6\frac{1}{2}$ inches wide, and $3\frac{1}{2}$ inches thick. Its form is irregular and distinctly fragmental; there are nine or ten faces, each of them slightly concave or convex; the edges are rounded. Five of the faces are similar to each other in character, and except for minute pittings and projecting points, are smooth; they show those large concavities which are common on meteoric stones, and have been likened in shape to 'thumb-marks'; the remaining faces are different in aspect, and have a low ridge-and-furrow development; they are doubtless due to fractures during the passage of the stone through the earth's atmosphere, possibly to the break-up at the moment of detonation. A crack going nearly half-way through the meteorite at a distance of an inch from an outer face was probably caused by impact on the larger stone met with in the soil. The meteorite is virtually completely covered with the characteristic crust

which is formed during the passage of such bodies through the air; the crust is in parts black, in parts brown, perhaps owing to the influence of the soil. On the smoother faces already referred to, the crust is thicker than, and different in aspect from, that on the remaining faces. From this it is inferred that the meteorite broke up in the earth's atmosphere at an early part of its course, when the speed was still so enormous that the heat produced by compression of the air in front of the quickly moving stone was sufficient to scorch the newly broken surface, for a fresh fracture of the stone is quite light in colour. In one part the crust is iridescent in purple, blue, and pink colours. Here and there bright particles of a metallic alloy of iron and nickel interrupt the continuity of the dark crust. On one of the smaller surfaces of latest fracture there is visible a section of a large flat nodule of the bronze-coloured protosulphide of iron, troilite, which is a characteristic mineral constituent of meteorites, and is not found as a native terrestrial product. Owing to the presence of particles of nickel-iron dispersed through the stony matter, the meteorite affects the magnetic needle, though not to a great extent. A mould of the meteorite has been made from which models will be prepared; a detailed mineralogical and chemical examination of the material of the stone will be at once begun."

The Bjurböle Meteorite.—Wilhelm Ramsay and L. Borgström contribute to the Bulletin de la Commission géologique de Finlande (No. 12, 1902) a full account of this fall, which occurred on the 12th March, 1899. It smashed through the ice which covered the fjord, and bedded itself in the mud to the depth of six metres. The ice at the point was 40 cm. thick, and fortunately there was only 90 cm. of water, so its recovery was not difficult. It was recovered in several pieces, the total weight of the lot being 328 kilograms. Its chemical composition seems to be of especial interest, but we have not room for further detail, and must refer the reader to the original paper. Bjurböle is about 50 kilometres N.E. of Helsingfors.

IX.—Short Notices.

1. Pliocene Voles.—Dr. Forsyth Major has studied the Voles from the Upper Val d'Arno and the Norwich Crag, and his results are embodied in a valuable note in the Proceedings of the Zoological Society of London, just issued. According to Dr. Major, Mr. Newton's *Microtus intermedius* forms a well-defined group of these animals, not a species, and is raised to the rank of a genus, *Mimomys*. Three species are defined altogether, but the author wisely says, "I am, however, quite convinced that at least double this number of species ought to be recognised, and am only prevented from doing so at present because I do not wish to found species on isolated teeth," remarks which might well be taken to heart by describers of scraps and fragments of bone and other imperfect and indeterminable material.

2. Carboniferous Arachnids. — When studying the Arachnida from the Permian of Bohemia for my work "Fauna der Gaskohle" (says Professor Dr. Anton Fritsch), I came to the conclusion that no

definite judgement was possible, before the Arachnida figured and described by Corda and Kusta from the Bohemian Carboniferous had been re-examined. Towards the conclusion of the work mentioned above, I took this in hand and prepared a work with many plates and restorations, which work will perhaps appear before the end of the year. I came to the following results, which are here noted since they interest a wide circle.

Cyclophthalmus senior, Corda, has no circle from the lateral to the large middle eyes, but there are merely angular granules on the median keel, as one sees in recent Buthidæ.

The restored figures of the eyes of *Cyclophthalmus*, which Corda gives on p. 37, as well as those of recent *Androctonus*, are fanciful and have no basis in fact.

Such position of the eyes as Corda figures for *Androctonus* exist in no known scorpion, and must have arisen from his mistaking the granules of the median keel for eyes.

Cyclophthalmus has merely two large median eyes, and, anteriorly on each edge, three lateral eyes, as in the recent *Buthus*. I have observed the latter in two species.

The Anthracomarta belong to the Trogulidæ, and it was necessary to settle which of the portions represented in the impressions belongs to the upper and which to the under sides. *Eophrynus* comes near to *Trogulus*, and has nothing to do with *Phrynus*.

The various genera of spiders which Kusta has described belong to the Arthrolycosidæ, which are the forerunners of the Mygalidæ.

The spider from Nyran (*Promygale*) shows by the possession of marginal plates a connecting link between the Trogulidæ and the Arthrolycosidæ.—*A. Fritsch*, Zool. Anzeiger, xxv, 16 June, 1902.

3. First Steps in Photo-micrography. By F. Martin Duncan, F.R.H.S. (the Amateur Photographer's Library, No. 25). Crown 8vo; pp. 104, with 16 text figures. (London: Hazell, Watson, & Viney, Ltd., 1902. Price 1*s.* nett.)

In this little work the author describes the methods and apparatus for use in low- and high-power photo-micrography; also development, printing, and lantern-slide making. The work is manifestly the result of the author's own practical experience, aud will be of great service to geologists who desire to produce their own photographs and to make lantern-slides of minute objects.

4. *Acrothyra* and *Hyolithes*: a Comparison. By G. F. Matthew, D.Sc. Trans. Roy. Soc. Canada, ser. II, vol. vii, sec. iv, p. 93.

Having described a new genus of Brachiopods from the Basal Cambrian rocks of Cape Breton, Dr. Matthew proceeds to compare it with the genus *Hyolithes*, in which he finds analogous conditions of growth and musculation. *Acrothyra*, the new Brachiopod, is very like in form to the obtuse tubes of certain *Hyolithes*, and appears to have lived under somewhat similar conditions.

A close comparison of the muscular systems in these two forms shows some points of resemblance, and others of radical difference; the two forms, therefore, are not supposed to be very closely related, but to be independent types, separately developed from the Worms.

5. *Hyolithes gracilis* and Related Forms from the Lower Cambrian of the St. John Group. By G. F. Matthew, LL.D. Trans. Roy. Soc. Canada, ser. II, vol. vii, sec. iv, p. 109.

A very slender form of *Hyolithes*, a variety of *H. gracilis* of the *Paradoxides Œlandicus* (cf. *P. Tessini*) zone, from a somewhat lower horizon, is described in this paper. The form resembles *Orthotheca Hermelini*, Holm, from the base of the Cambrian in Sweden, but has a more projecting dorsal lip. Figures are given to show the forms of this species found in the St. John Group. The shell has several chambers in the apex, and so is of the subgenus *Camerotheca*. The operculum was not found.

REVIEWS.

Memoirs of the Geological Survey of England and Wales. (London, E. Stanford, and of all booksellers.)

1. The Geology of the Country around Southampton (Explanation of Sheet 315).[1] By Clement Reid, F.R.S.; with contributions by W. Whitaker, F.R.S. 8vo; pp. 70, with illustrations of Chalk and London Clay fossils, also Palæolithic implements and geological sections. (1902. Price 1*s.* 6*d.*)

THIS area comprises a part of the Hampshire Basin formed of Chalk and Tertiary strata, and modified by some minor undulations in the strata. Thus the Portsdown anticline, which occurs to the east, has been shown to affect the area from the occurrence of several new inliers of London Clay (pp. 10 and 41).

Special attention is directed to the fossils of the London Clay and Bracklesham Beds; and to the flint implements of the plateau and valley deposits, which are illustrated. So many and varied fossils occur in the Bracklesham Beds of the New Forest at Brook, Bramshaw, Huntingbridge, and Southampton, as shown by the lists given pp. 27–34 and p. 40, that a more liberal number and better quality of illustrations might well be expected. Indeed, the area is so extremely prolific in fossil remains that it deserves and will no doubt obtain a more extended memoir at no distant date.

Records are given by Mr. Whitaker of numerous well-sections.

2. The Geology of the Country around Exeter (Explanation of Sheet 25). By W. A. E. Ussher, F.G.S.; with Notes on the Petrology of the Igneous Rocks by J. J. H. Teall, M.A., F.R.S. 8vo; pp. 122, with 20 Illustrations in the text. (1902. Price 2*s.*)

IN this work there is an account of the unproductive Culm-measures, and full particulars of the subdivisions of the New Red Sandstone series which occupy a large portion of the country around Exeter.

Much interest attaches to the volcanic rocks which occur in the lower part of the New Red Sandstone, and a petrological description of these is contributed by the Director of the Geological Survey. There are notes also on the superficial deposits, water-supply, etc.

[1] This memoir has already been referred to in the Geological Magazine for October, p. 478.

A long interval may well have elapsed between the resurvey of the area and the publication of this Explanation, for we do not find any reference to the wonderful discovery by Dr. G. J. Hinde and Mr. Howard Fox[1] of Radiolarian rocks in the Lower Culm-measures, which embrace a large extent of the Exeter area, dealt with in this Memoir, although the paper was read before the Geological Society in June, 1895.

Palæontological evidence has been of late shown to be as important as ever to the stratigraphical geologist, and no 'Royal Hammerer' can afford to neglect it if he values his reputation for 'up-to-dateness.'

3. The Geology of the Country around Ringwood (Explanation of Sheet 314). By Clement Reid, F.R.S.; with contributions by F. J. Bennett, F.G.S., and E. E. L. Dixon, B.Sc., F.G.S. 8vo; pp. 62, with 4 Illustrations in text. (1902. Price 1*s*. Price of Sheet 314 and a colour-printed map of the Ringwood district, 1*s*. 6*d*.)

IT would be an excellent plan if with every Memoir published by the Survey the colour-printed map or sheet belonging to the Explanation were (as in this instance) found folded up inside the cover. It would add enormously to its worth.

A description is given in this Memoir of the north-west portion of the Hampshire Basin, including the fine range of Chalk hills bordering Cranborne Chase on the north-west, and a part of the picturesque woodland of the New Forest, formed of Tertiary strata, on the south-east.

Attention is called to the evidence of an old river-course, which, probably in Newer Pliocene times, connected the Salisbury rivers with Southampton. On p. 34 is given an explanation aided by a very useful diagram of the River Valley Terraces of the Avon, from 100 to 400 feet above sea-level, which Mr. Clement Reid divides into—(*a*) Pliocene (high plateau), 400 feet; (*b*) Early Glacial; (*c*) Eolithic (second terrace); (*d*) Palæolithic (first terrace); (*e*) Late Glacial (valley gravel); (*f*) Alluvium (100 feet), down to the present river channel.

Well-sections are given in an Appendix.

The map, which has been executed at the Ordnance Survey Office, is clearly and well printed on a scale of one inch to the mile; the names and boundaries are very legible and distinct, and the colours pleasing to the eye. The Geological Survey is certainly to be congratulated on the introduction of colour-printed one-inch maps.

4. Summary of Progress of the Geological Survey of the United Kingdom and of the Museum of Practical Geology for 1901. 8vo; pp. 220, with 7 Illustrations. (London, 1902. Price 1*s*.)

SAVE in the margin, there is no author's name to this work. The whole represents the Director's Report for the year 1901, and should have borne his name on the title-page, as the responsibility for it rests upon his shoulders.

[1] See Quart. Journ. Geol. Soc., vol. li (1895), pp. 609–668, pls. xxiii–xxviii.

The Summary contains a rather full account of the field-work of the Geological Survey in England and Wales, Scotland and Ireland, and of the chemical, petrological, and palæontological work in connection therewith, also the work of the Museums in London and Edinburgh.

Progress has been made in Cornwall and Devon in subdividing the great Killas formation, and even the Granite of the Land's End area has proved susceptible of critical subdivision. In the South Wales area the detailed examination of the Coalfield has proceeded as far west as Swansea, and some new inliers of Silurian rocks have been detected in Gower. The resurvey of the Midland Coalfields has been continued.

In Scotland further particulars have been obtained with regard to the Highland Schists and the various Granite masses. Cretaceous rocks have for the first time been noticed in Soay Sound and Scalpay.

In Ireland the Drifts have been surveyed in the Dublin area.

Analyses of South Wales Coals have been commenced, and some notes on weathering of Magnesian Limestone are published.

A list is given on pp. 94, 95 of various maps, sections, and memoirs issued during 1901 for England and Wales, e.g., Sheets 261 and 262 (Bridgend), in one map. Index Map, Sheets 8 and 11 have been revised, and Sheet 12 reprinted. Forty-nine manuscript coloured copies of 6 inch sheets and quarter-sheets have been deposited in the Office at Jermyn Street for public reference. Three sheets of vertical sections have been published. A list of memoirs and extra-official publications is added.

Details of the palæontological work performed in the Museum and Survey Office for Scotland in Edinburgh are given on pp. 177 to 182. Two sheets of the 1 inch map have been published—one of Arran, part of Bute, and the Cumbraes, the other of Loch Lomond, Loch Katrine, and Callander. A list is also given of extra-official publications for the year.

For Ireland thirteen 1 inch maps have been revised and issued at the Dublin Office. These maps relate almost entirely to the Ordovician and Silurian rocks of Ireland, and should prove of much interest to geologists. In Appendices A and B Mr. H. A. Allen furnishes lists of figured and type specimens of British fossil Phyllocarida and British Palæozoic Echinodermata preserved in the Museum of Practical Geology, London. We hope soon to see the whole of the types and figured specimens belonging to the Survey published separately; they will be of the greatest value to workers in palæontology.

We congratulate Mr. J. J. H. Teall, the Director of the Geological Survey, on the excellent work of 1901, and look forward to even greater results in 1902.

The Board of Agriculture desire to give notice that copies of all the Memoirs and Maps of the Geological Survey may be obtained from any agent for the sale of the Ordnance Survey maps, or through any bookseller from the Ordnance Survey Office, Southampton.

CORRESPONDENCE.

OFFASTER PILULA.

Sir,—Mr. Sherborn is right as to the unfortunate slip in the recently published Memoir on the Geology of Southampton. Having Dr. Barrois' book open before me when I wrote the paragraph, I seem to have forgotten for the moment the more recent authorities. Elsewhere I have correctly referred the highest Chalk in that neighbourhood to the zone of *Actinocamax quadratus*.

Clement Reid.

October 8th, 1902.

LAKES OF SNOWDONIA.

Sir,—In my letter which appeared in the September number of your Magazine (p. 430, line 16 from top of letter) is an erratum which destroys the significance of the sentence. For 'sunny' read 'snowy.'

J. E. Marr.

Cambridge, *October 9th*, 1902.

RIVER DEVELOPMENT.

Sir,—Because I frankly admitted that statements in my paper in *Natural Science*, vol. xiv, 1899, might be termed "mere speculation," giving as the reason that the maps which we can obtain do not supply sufficient information for the precise study required, Mr. Strahan thinks he was justified in characterizing my work as "transgressing the limits of legitimate speculation." Yet he had just admitted not having seen the paper in *Natural Science* when he made that remark.

There is all the difference between my admission and Mr. Strahan's remark. Any theory is a speculation. I gave the grounds on which the theory was based; and I followed out the logical conclusions. The basis of the theory is that the original rivers flowed with the dip. As the general dip of the area in question is from north-west to south-east, that involves an original river-system such as was depicted in my map. Strong evidence in favour of the theory is found in the peculiar course of the tributaries on the left bank of the Severn, and in the breaches of the Cotteswold escarpment.

It is difficult to admit that in a country of simple structure such as the Cotteswolds, a Chalk anticline and all that it involves could be masked.

As to the indefinite westerly rise of the Chalk, is it so very great? The rise of the Oolitic surface on which the Chalk could have rested is about 800 feet in 25 miles. Having regard to the thickness of the Chalk and the extent of its outcrop, can its rise be much more than this?

One word about the Moreton anticline. I described *an* anticline there, formed and covered over again in Inferior Oolite time. We

need not suppose this was *the only* anticline. On the principle of "successive movements along the same line of weakness," there were probably several successive upheavals along the line of the Moreton Valley. One such upheaval may have been post-Cretaceous, only the axis of such anticlines runs north and south.

S. S. Buckman.

MISCELLANEOUS.

Retirement of Mr. Frederick William Rudler, F.G.S.

To those at all well acquainted with the geological, mineralogical, and mining worlds of London, no name or presence is more familiar at meetings of scientific men, or as a lecturer and speaker, than that of Mr. F. W. Rudler, the eminent Curator of the Museum of Practical Geology at the Geological Survey in Jermyn Street, S.W.

Mr. F. W. Rudler (who retired September 30th) has filled the post of Curator and Librarian to the Museum of Practical Geology since the death of Mr. Trenham Reeks in 1879. Prior to this Mr. Rudler was for three years Professor of Natural Science in the newly-formed University College at Aberystwith, a post which he relinquished at the urgent request of the late Sir A. C. Ramsay, in order to take up the Curatorship of the Jermyn Street Museum. In earlier years, from 1860 to 1876, Mr. Rudler was Assistant Curator, and during this period he prepared new editions of the Descriptive Guide to the Museum, and also of the Catalogue of Pottery and Porcelain, works which are full of expert knowledge.

As a lecturer and public speaker Mr. Rudler is widely appreciated on account of his clear and admirable exposition of whatever scientific subject he undertakes to discourse upon, and we trust that in this respect his career may long continue. As a referee on all matters within his wide domain, he has been unequalled. Like Monsieur Houdin's wonderful bottle, no matter upon what particular subject one may require his assistance, his sources of knowledge have proved both varied and unfailing and have only been equalled by the readiness, the excessive kindness and amiability with which he at once has imparted his knowledge to all. As Treasurer of the International Geological Congress (London) in 1888, his energy, ability, and tact contributed largely to render that meeting memorable. Mr. Rudler has been for long a writer for the *Athenæum* and other journals, and is one of the best-informed men on all branches of scientific literature, while having a special knowledge of mineralogy, anthropology, and ceramic art. His absence from his accustomed study in the Museum at Jermyn Street will long be keenly felt by those who have been privileged to know and consult him. He will be succeeded by Mr. J. Allen Howe, B.Sc., whose training at the Royal College of Science and subsequent work on the Geological Survey well qualify him for the arduous post to which he has been appointed.